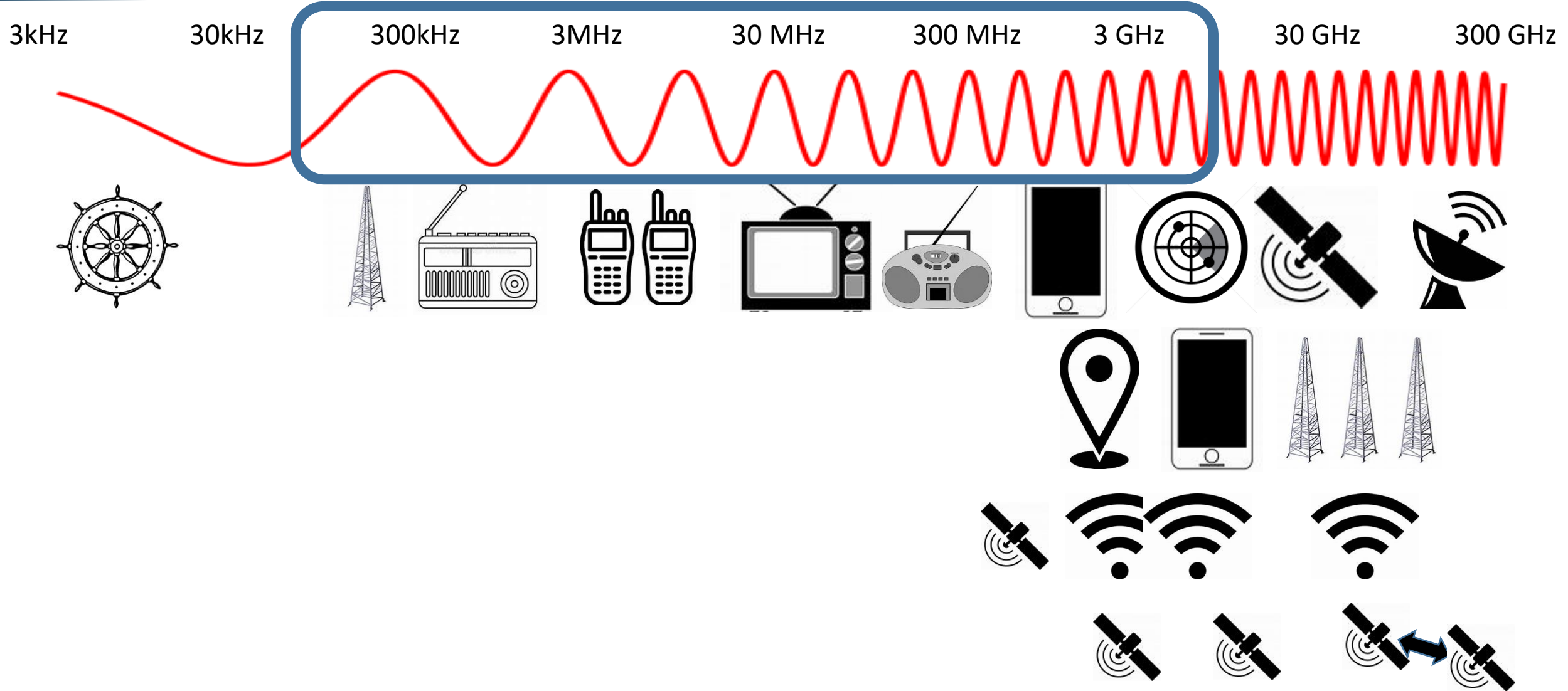


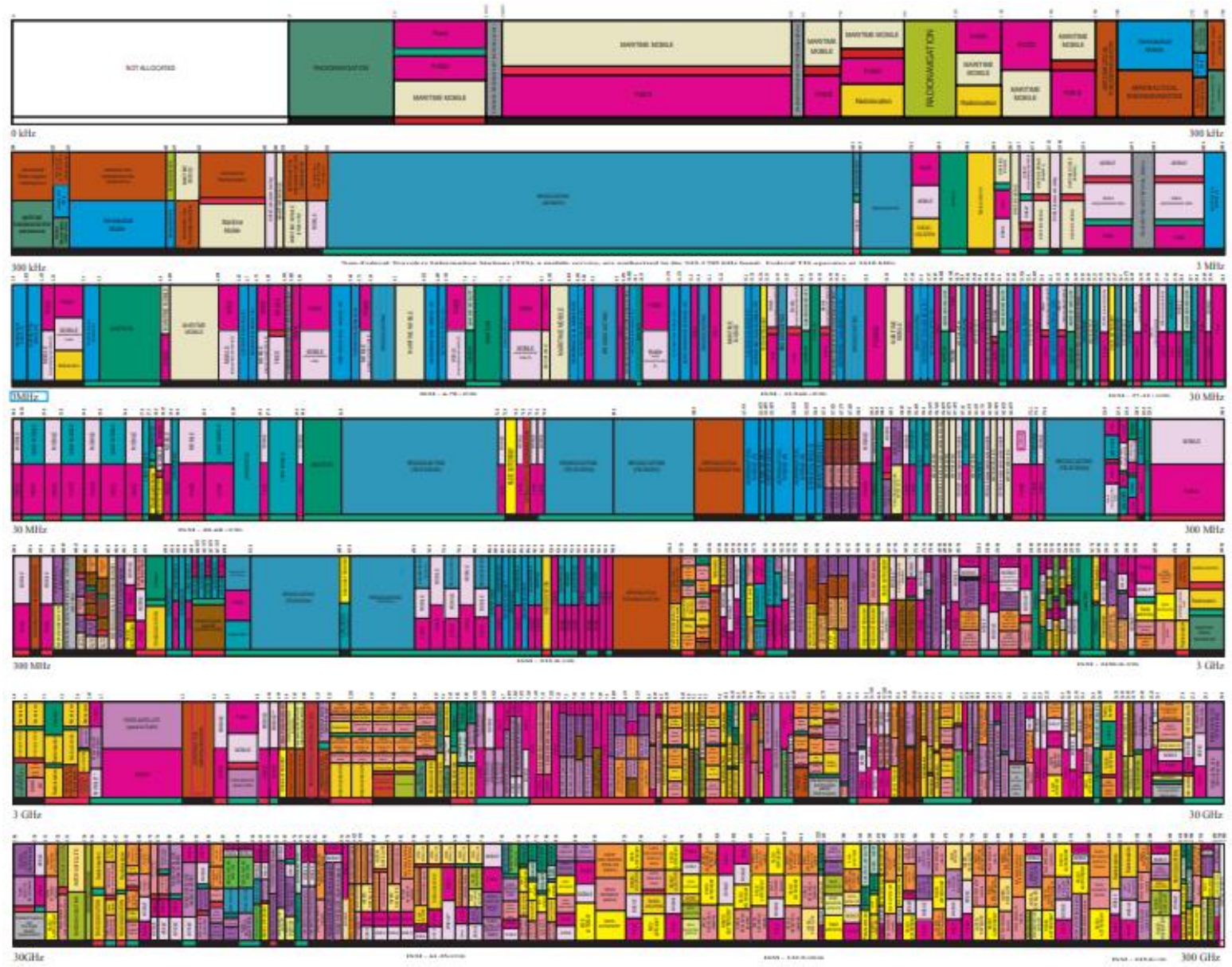
# Meeting the High Frequency Challenge

*March 2019*



# Does anyone else feel crowded ??





# Why Go Higher ... ?

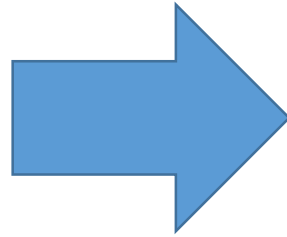
---

Data Throughput

Resolution

Spectrum congestion

Wired to Wireless  
Economies of Scale



Spectral Efficiency

Higher Operating  
Frequencies

# Technology Advancements

---

- High frequency component and solution design requires more than just the next new semiconductor node
- Sometimes it's simply a matter of applying 2 existing technologies to deliver a high performance solution
- Often times new products come from thinking about the problem from a different perspective or using a tool in a new way
- Products and Technology innovations that have helped our customers solve high frequency system challenges



# Low Current Wideband Amplifier

DC to 20 GHz

## Key Features

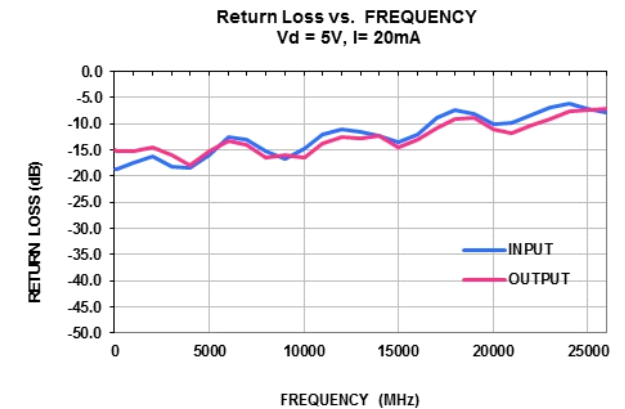
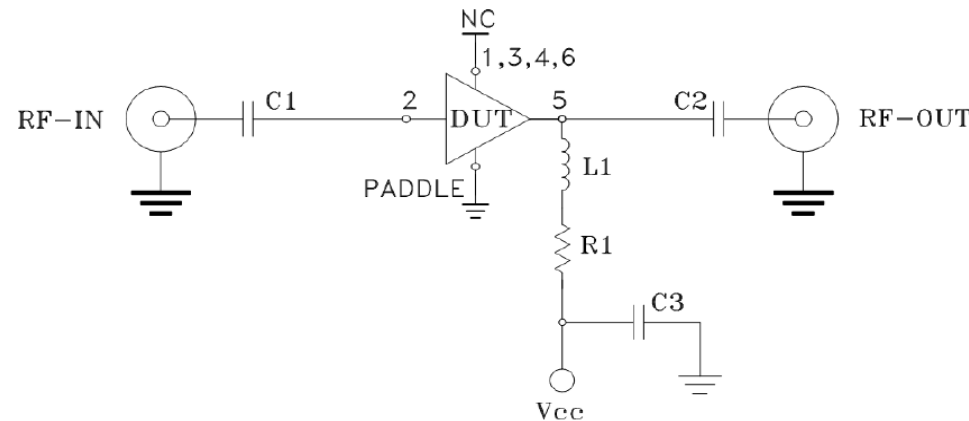
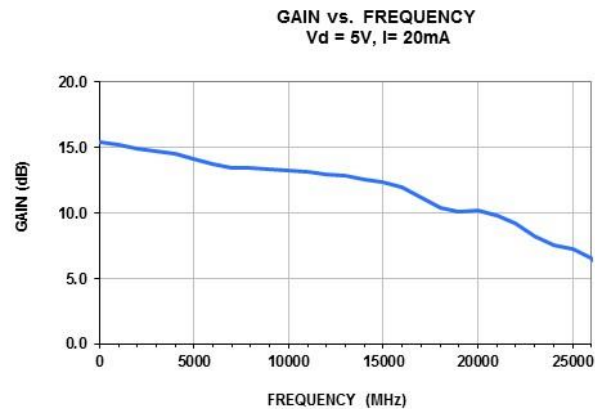
- Super wideband: DC to 20 GHz
- Low current: 20mA
- Good input & output return loss: > 10dB
- Repeatable performance (HBT Process)

## Markets

- Instrumentation
- CATV
- Telecommunications
  - 5G



**EHC-24L+**



# Medium Power, Wideband Amp

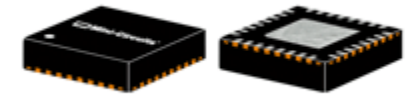
13 to 26.5 GHz

## Key Features

- Wideband performance
- Excellent gain flatness, over temperature
- Output Power: up to 27 dBm
- Unconditional stability
- Small, thermally efficient package

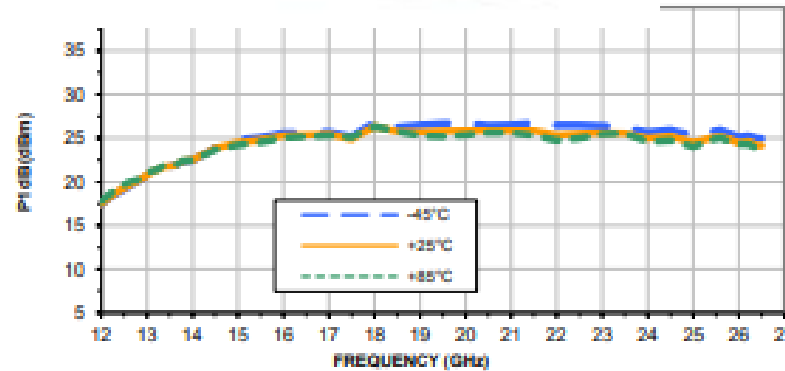
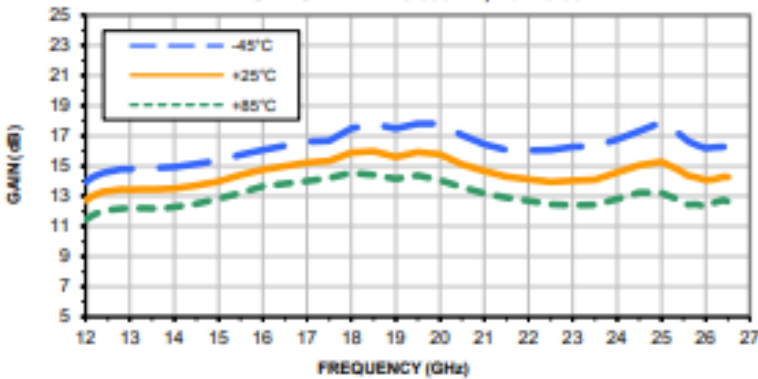


Communications  
Space and Defense  
etc.

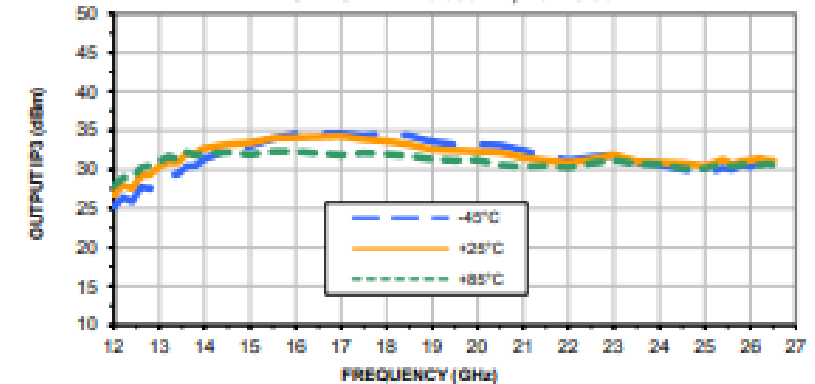


**AVM-273HP+**

GAIN vs. FREQUENCY & TEMPERATURE  
INPUT POWER = -25.00dBm, Vd = 5.00V



OUTPUT IP3 vs. FREQUENCY & TEMPERATURE  
INPUT POWER = 0.00dBm, Vd = 5.00V



# Wideband Gainblock Amplifier

0.05 to 40 GHz

## Key Features

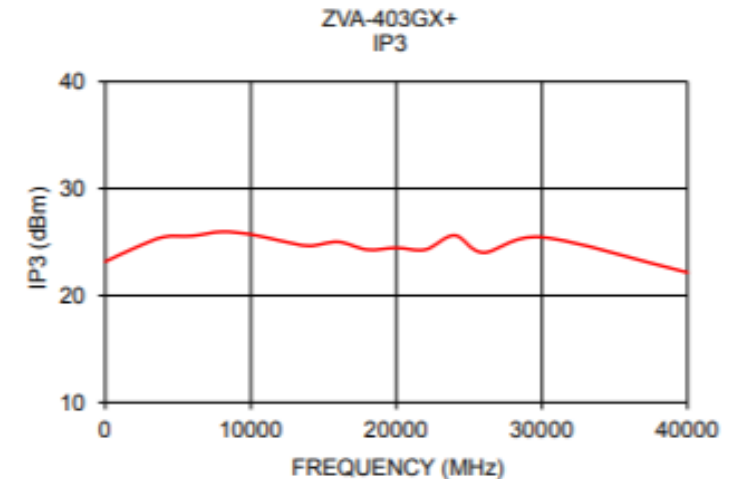
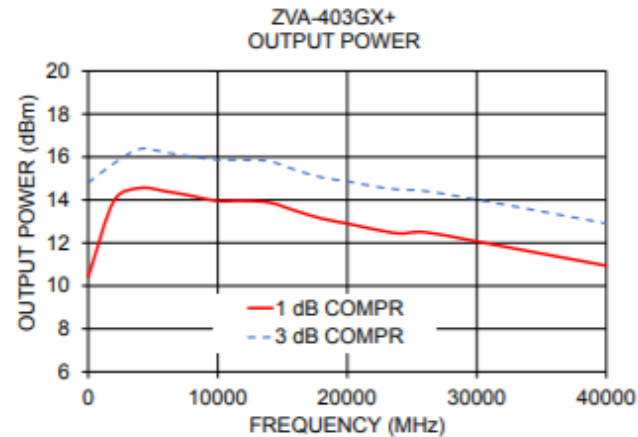
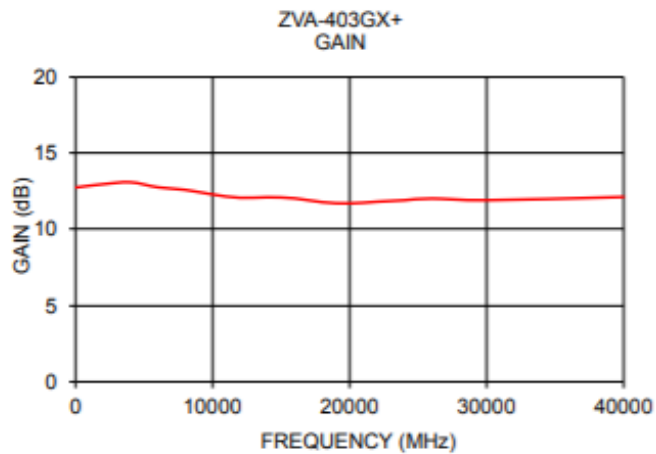
- Gain: 11 dB typ.
- P1dB: 10 dBm typ.
- IP3: 21 dBm typ.
- Noise figure: 4.0 dB
- 2.92 mm F/F connectors

## Markets

- Test and Measurement
- Telecommunications
  - 5G
- Aerospace and Defense



**ZVA-403GX+**





# Wideband Double Balanced Mixer

10 to 40 GHz Level 15 (LO Power 15 dBm)

## Key Features

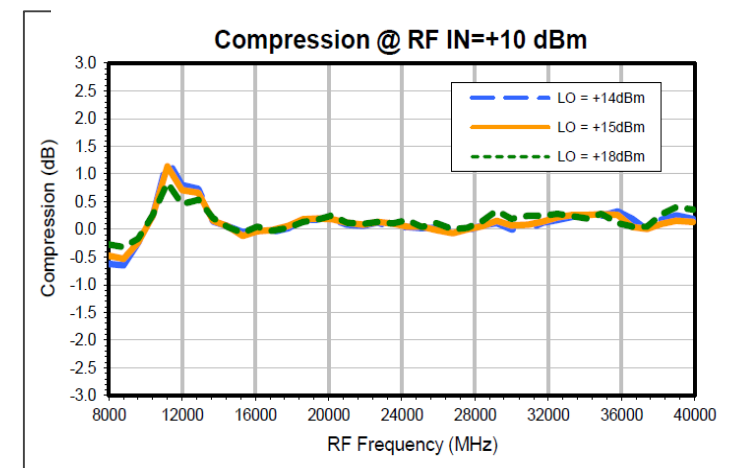
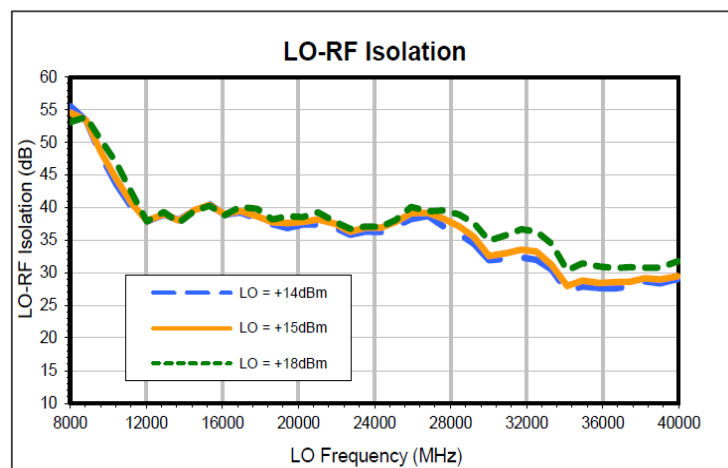
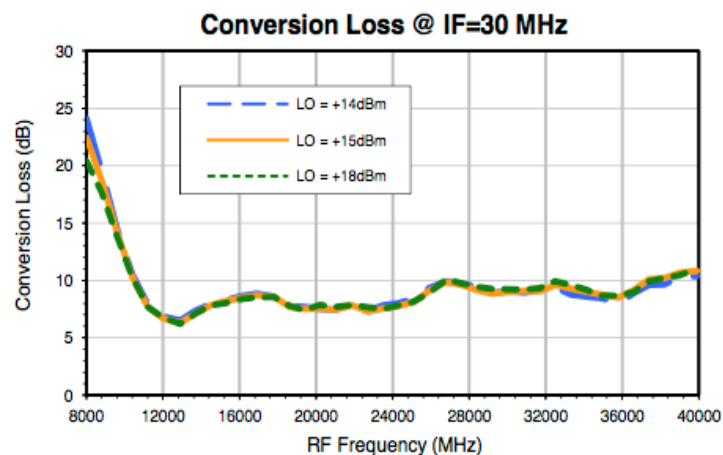
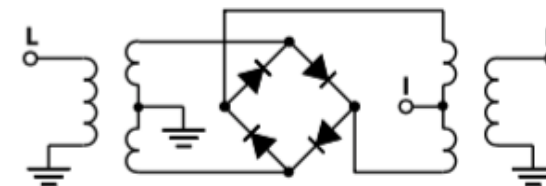
- LO-RF isolation: 37 dB typ. at 25 GHz
- Conversion loss: 8.4 dB typ.
- P1dB: 10 dBm typ.
- IP3: 20 dBm typ.
- Usable as up & down converter

## Markets

- Satellite
- Aerospace and Defense
- Telecommunications
  - 5G



**MDB-44H+**



# MMIC Frequency Doubler

12.4 to 40 GHz

## Key Features

- Ultra wideband output
- Wide input power range: 12 – 18 dBm
- Low conversion loss: 14 dB
- Good fundamental and harmonic suppression:  
F1: -26dBc F3: -34dBc

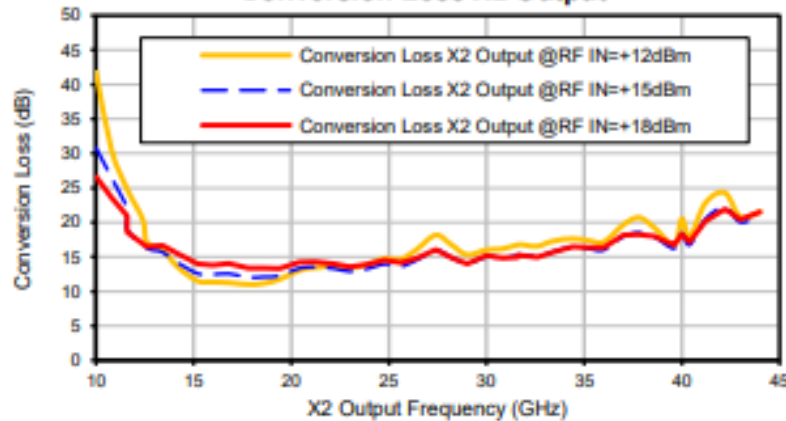
## Markets

- Telecommunications
- Aerospace and Defense

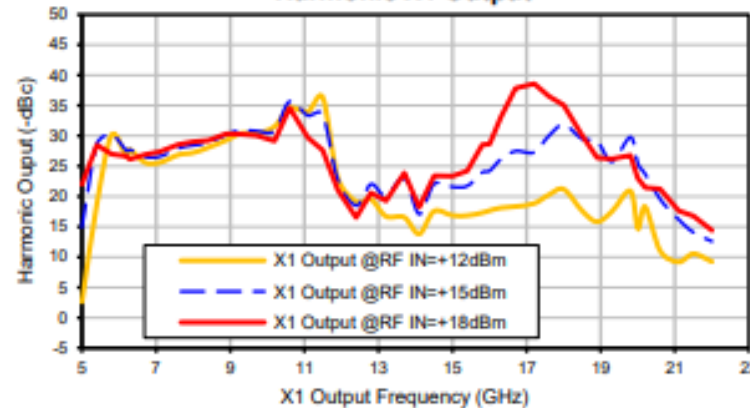


CY2-44+

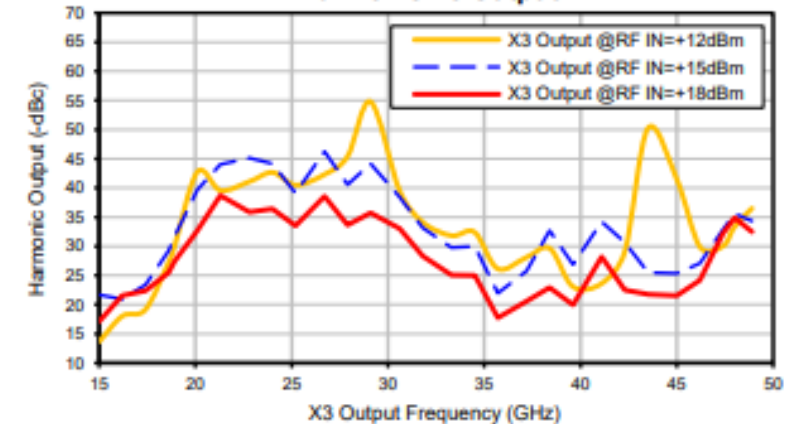
Conversion Loss X2 Output



Harmonic X1 Output



Harmonic X3 Output



# 2 Way 0° Power Splitter / Combiner

5000 to 43500 MHz

## Key Features

- Up to 43.5 GHz in a molded package !
- Ultra wide bandwidth
- High power handling as splitter: up to 2.5 watts
- Exceptional amplitude balance: < 0.2 dB
- Small size: 4 x 4 x 1 mm & 3.5 x 2.5 x 0.85 mm



EP2K Series

**New Case Style**  
**MCLP 3.5 x 2.5 10L**

Model Number	Frequency Range (MHz)		Isolation (dB)	Insertion Loss (dB)	Phase Unbalance (Degrees)	Amplitude Unbalance (dB)	VSWR (:1) Typ.	Power Handling (Watts) Max.
	Low	High	Typical	Typical	Typical	Typical		
EP2K+	5000	20000	20	1.7	3.6	0.1	1.4	2.5
EP2K1+	2000	26500	20	1.7	3.6	0.1	1.4	2.5
EP2KA+	10000	43500	22	0.9	6.1	0.2	1.4	1.0

# High Power, Splitter / Combiners

0.5 to 26.5 GHz 2-8 Way 0°

## Key Features

- High isolation minimizes interference between ports
- High power handling: 20 Watts as a splitter
- Excellent return loss: better than 1.6:1
- Rugged aluminum alloy case
- Connectors: 2.92 mm F/F



**ZCxD Series**

Model	Frequency Range (GHz)	Type	Power Input as Splitter (W), Max.	Isolation (dB), Typ.	Insertion Loss (dB), typ.	Phase Unbalance (Degrees) +/-, Max	Amplitude Unbalance (dB) +/-, Max	VSWR In/Out (:1) Typ
ZC2PD-5R263-S+	0.5-26.5	2 Way 0°	20	17	2.4	4	0.4	1.6/1.6
ZC2PD-01263-S+	1-26.5	2 Way 0°	20	17	1.6	4	0.3	1.5/1.5
ZC2PD-02263-S+	2-26.5	2 Way 0°	20	18	1.2	3	0.3	1.5/1.5
ZC2PD-06263-S+	6-26.5	2 Way 0°	20	17	1.2	3	0.3	1.5/1.5
ZC4PD-01263-S+	1-26.5	4 Way 0°	20	16	3.2	6	0.5	1.6/1.6
ZC4PD-02263-S+	2-26.5	4 Way 0°	20	17	2.7	5	0.4	1.6/1.5
ZC4PD-K0244+	2-40	4 Way 0°	20	16	3.8	6	0.5	1.6/1.6
ZC8PD-06263-S+	6-26.5	8 Way 0°	20	16	2.9	6	0.6	1.6/1.6

# High Power, Splitter / Combiners

10 to 65 GHz 2-8 Way, 0°

## Key Features

- High isolation minimizes interference between ports: >20 dB
- High power handling: 10-20 Watts
- Rugged aluminum alloy case
- Connectors: 2.92 mm-F



**ZNxPD Series**

Model	Frequency Range (GHz)	Type	Power Input as Splitter (W) Max.	Isolation (dB) Typ.	Insertion Loss (dB) Typ.	Phase Unbalance (Degrees) Max	Amplitude Unbalance (dB) Max
ZN2PD-K44+	10 to 40	2 Way 0°	10	20	0.8	7	0.2
ZN4PD-K44+	10 to 40	4 Way 0°	20	22	1.5	6	0.3
ZN8PD-K44+	10 to 40	8 Way 0°	20	20	2.0	8	0.4
ZN2PD-V54+	10 to 50	2 Way 0°	10	20	1.8	10	1.0
ZN2PD-E653+	10 To 65	2 Way 0°	10	20	2.0	15	1.5



# MMIC Directional Coupler

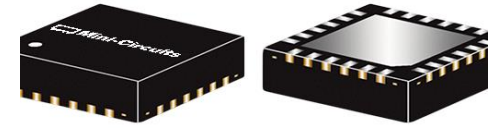
6 to 26.5 GHz

## Key Features

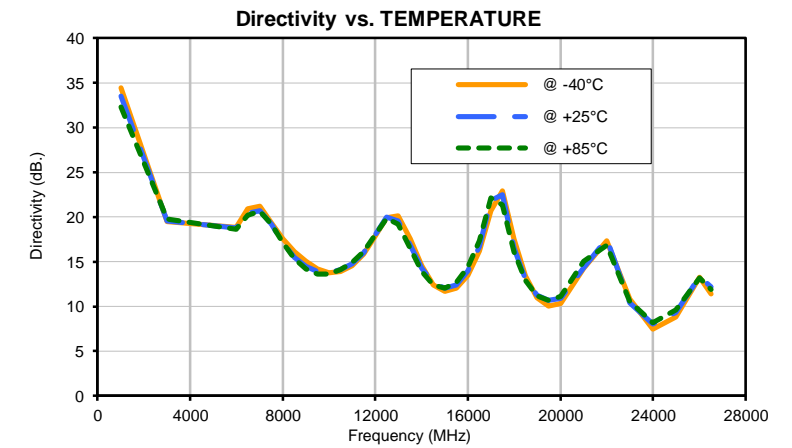
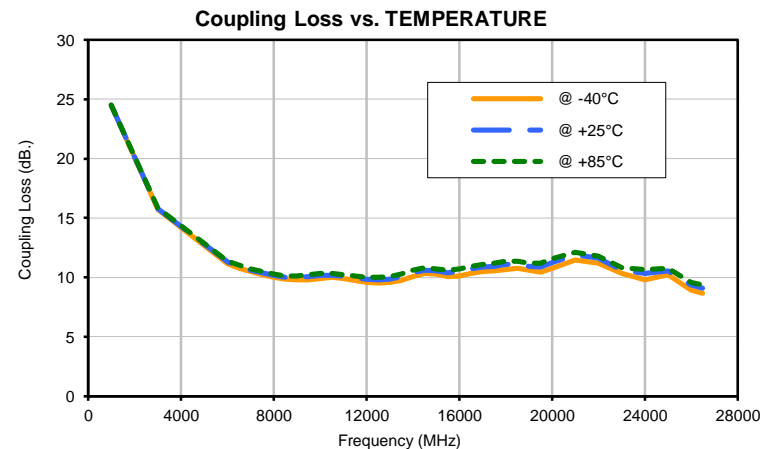
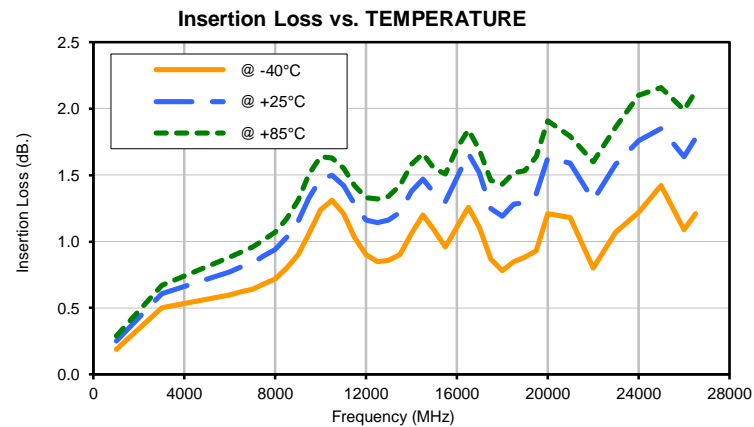
- Very wideband: 6-26.5 GHz
- Excellent coupling flatness:  $10 \pm 1.5$  dB typ.
- Small Size: 4 x 4 mm
- No external termination required

## Markets

- Satellite
- Telecommunications
- Test and Measurement



**EDC10-273+**



# Wideband Bi-Directional Coupler Die

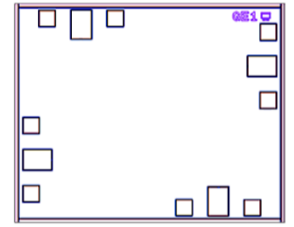
5 to 43.5 GHz

## Key Features

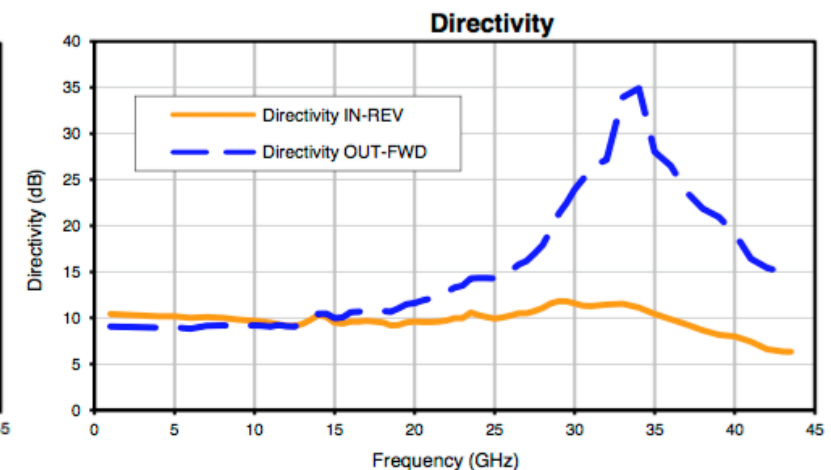
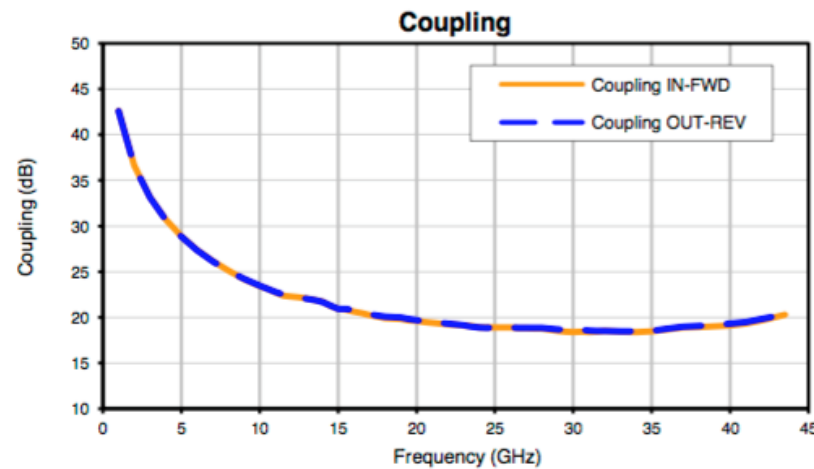
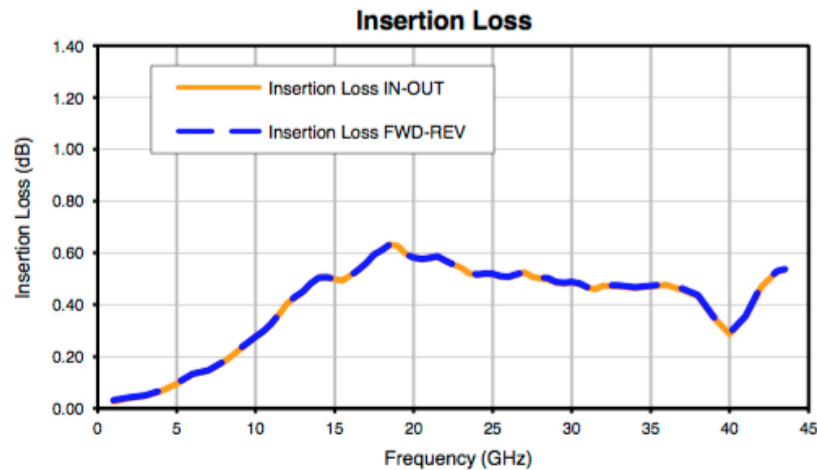
- Wide bandwidth
- Excellent coupling Flatness,  $\pm 0.6$  dB over 20 to 40 GHz
- Nominal Coupling 18.6 dB over 20 to 40 GHz
- DC passing

## Markets

- Aerospace and Defense



**EBDC19-KA-D+**



# High Power Directional Couplers

0.5 to 40 GHz

## Key Features

- Wideband, 10-30 dB Coupling
- Insertion loss: as low as 1 dB, typ.
- Coupling Flatness: as low as 0.5 dB, typ.
- DC current pass through input to output



**ZCDC Series**

Model	Freq. Range (GHz)	Coupling (dB) Typ.	Coupling Flatness (dB), Typ.	Mainline Loss (dB) Max.	Directivity Up to 4 GHz (dB), Min.	VSWR (:1) Max.	Power Input (W) Max.
ZCDC10-K5R44W+	0.5 to 40	10	+/- 1.0	3	11	1.7	1
ZCDC10-02263S+	2 to 26.5	10	+/- 0.5	1.5	13	1.5	1
ZCDC20-02263S+	2 to 26.5	20	+/- 0.5	1	14	1.5	1
ZCDC10-K0244+	2 to 40	10	+/- 0.6	2.1	10	1.7	1
ZCDC20-K0244+	2 to 40	20	+/- 0.8	1.5	10	1.7	1
ZCDC30-5R263+	2 to 26.5	30	+/- 0.8	1.9	16	1.5	1

# Waveguide Bandpass Filters

## 28 to 83.5 GHz Center Frequency

### Key Features

- Low insertion loss: 0.3 - 0.6 dB, Typ.
- Super-high rejection: > 25-39 dB, upper stop band
- Excellent return loss: > 18 dB



**WVBP-xxx-WR12+**

Model Number	Passband F1 (GHz)	Passband F2 (GHz)	Insertion Loss (dB), Typ	Stopband F3 (GHz)	Rejection @ F3 (dB), Typ	Stopband F4 (GHz)	Rejection @ F4 (dB), Typ
WVBP-283-WR28+	27.5	28.35	0.5	22-27	30	28.85-38	39
WVBP-383-WR28+	37	40	0.6	22-36	49	41-42	25
WVBP-613-WR15+	57.2	65.9	0.4	50-56.2	44	66.9-75	31
WVBP-673-WR12+	64	71	0.3	60-61.5	39	73.5-90	26
WVBP-733-WR12+	71	76	0.6	60-69.5	56	77.5-90	39
WVBP-783-WR12+	76	81	0.6	60-74.5	33	82.5-90	29
WVBP-833-WR12+	81	86	0.5	60-79	38	88-90	26

# Reflectionless High Pass Filters

## 9.1 to 40 GHz F3-F5

### Key Features

- Low insertion loss: 1.3-2.7 dB
- High rejection: > 18 dB in die form
- Excellent return loss: > 12 dB



**XHF2 and XHF**

Model Number	Passband F3-F5 (GHz)	Passband F2 (GHz)	Insertion Loss (dB), Typ	Stopband F1 (GHz)	Rejection @ F1 (dB), Typ
XHF-153-D+	15000-40000	14400	2	DC-12	20.7
XHF-912-D+	9100-40000	8400	1.5-1.6	DC-7.3	20.5
XHF-1162-D+	11600-40000	10500	1.3-1.8	DC-9.1	21.3
XHF-1352-D+	13500-40000	12700	1.3-2.3	DC-10.5	22.5
XHF-1832-D+	18300-40000	17400	1.3-1.8	DC-14.6	18.3
XHF2-153+	15300-30000	14200	2.2-2.7	DC-12	13.7
XHF2-912+	9100-30000	8200	2.1-2.7	DC-7.1	14.3
XHF2-1162+	11600-30000	10400	1.8-2.7	DC-8.7	13.6
XHF2-1352+	13500-30000	12700	1.8-2.7	DC-10.5	13.8
XHF2-1832+	18300-30000	17500	1.7-2.8	DC-14.6	14.0



# Microwave Gain Equalizers

**New Product Line**

DC to 20 GHz

## Key Features

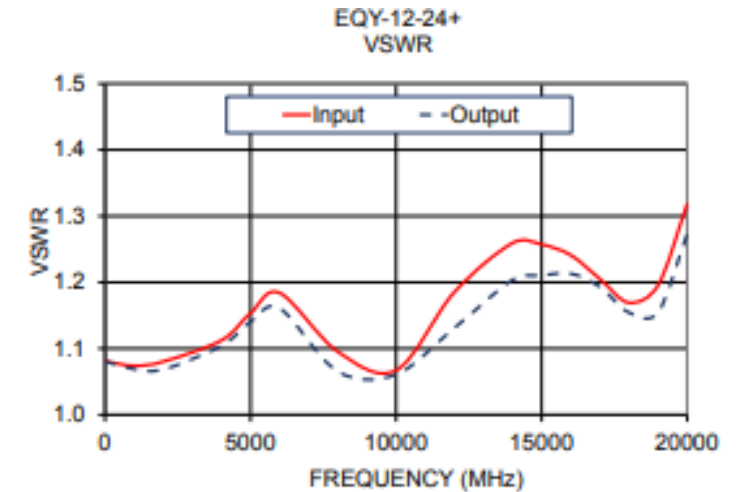
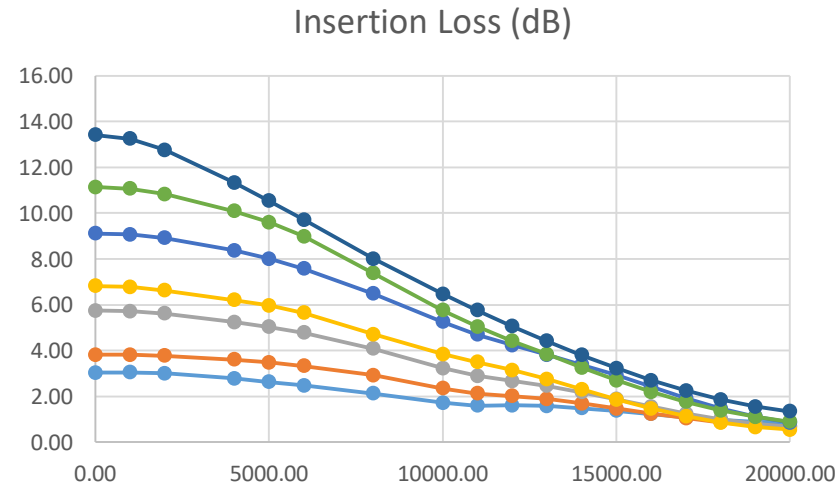
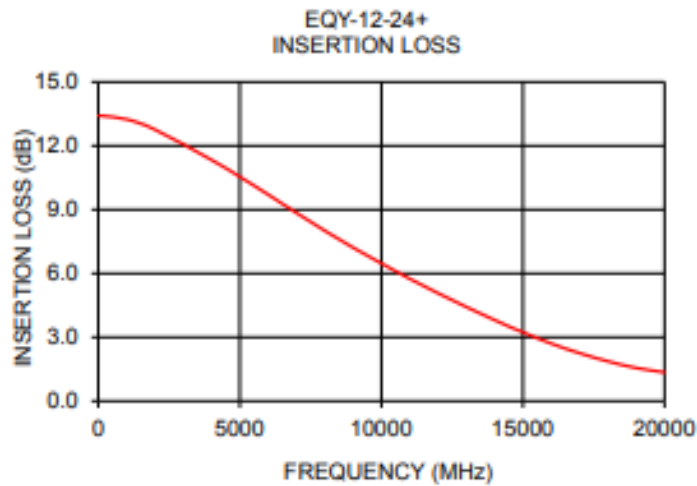
- Wide bandwidth
- Multiple slope selection (2, 3, 5, 6, 8, 10 & 12 dB)
- Excellent return loss, 20 dB typ.
- Excellent power handling
- Small package, 2 x 2 mm

## Markets

- All Markets



**EQY-X-24+**



# Hermetic Precision Attenuators

DC to 20 GHz

## Key Features

- Ceramic, hermetically sealed, high reliability
- Broad frequency range
- 0-30 dB attenuation values
- Up to 2 Watts power handling
- Very good return loss



**RCAT Series**

Model Number	Freq. Low (MHz)	Freq. High (MHz)	Attenuation (dB) Nom.	Attenuation variation (dB), typ.	Return Loss (dB), typ.	Power Input Max. (W)
RCAT-00+	DC	20000	0	+/- 0.25	20	2
RCAT-03+	DC	20000	3	+/- 0.5	20	2
RCAT-10+	DC	20000	10	+/- 1.1	20	2
RCAT-20+	DC	20000	20	+/- 3.5	21	2
RCAT-30+	DC	20000	30	+/- 1.0	20	2

# Microwave Precision Fixed Attenuator

DC to 40 GHz

## Key Features

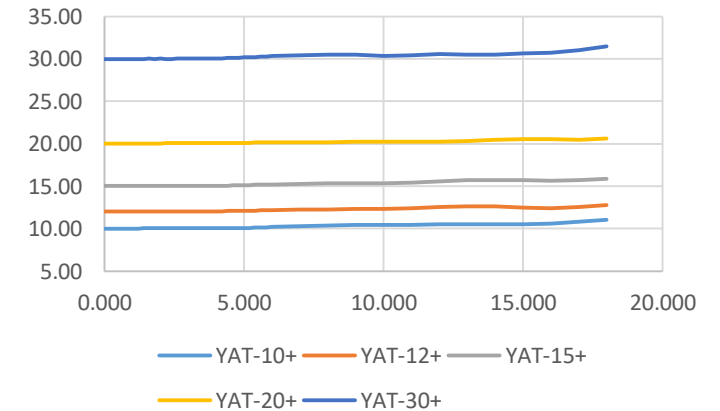
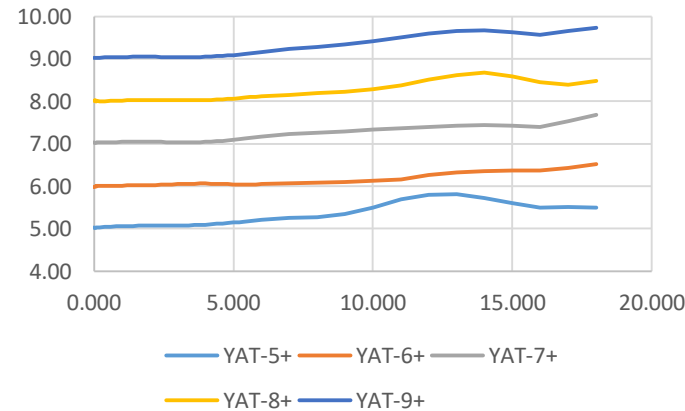
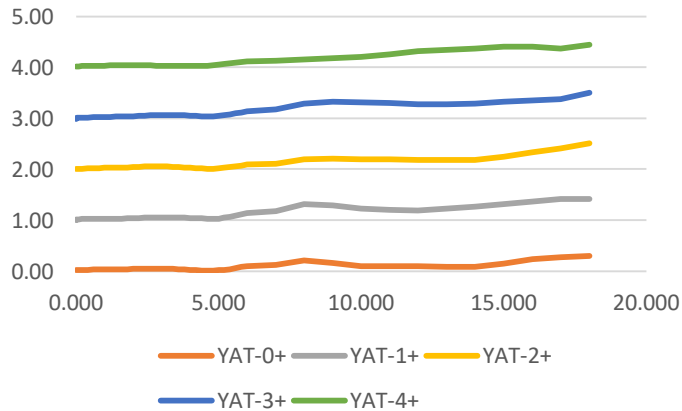
- Super wide bandwidth
- Wide range of nominal attenuation values (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 30)
- High power handling, up to 2W
- Small size, available in die form and 2 x 2 mm

## Markets

- All Markets



YAT-X+, YAT-X-D+



# Microwave Precision Fixed Attenuator

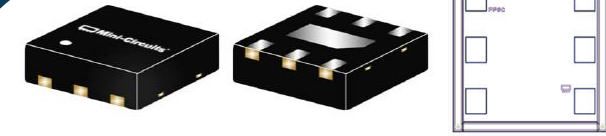
DC to 40 GHz

## Key Features

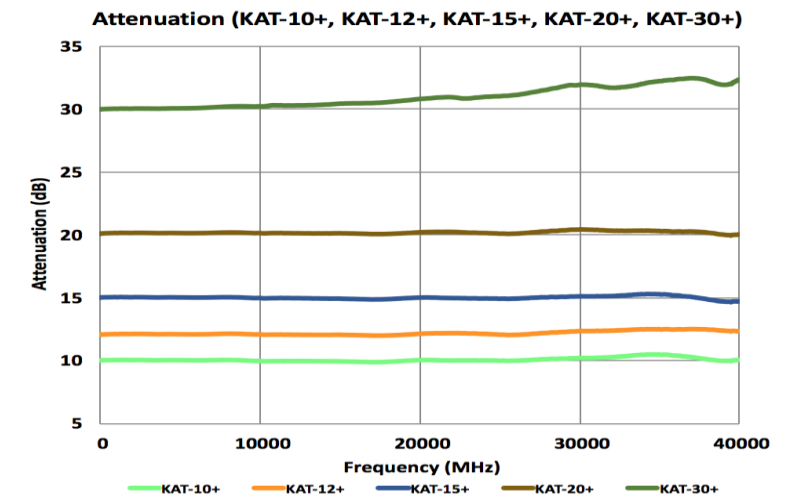
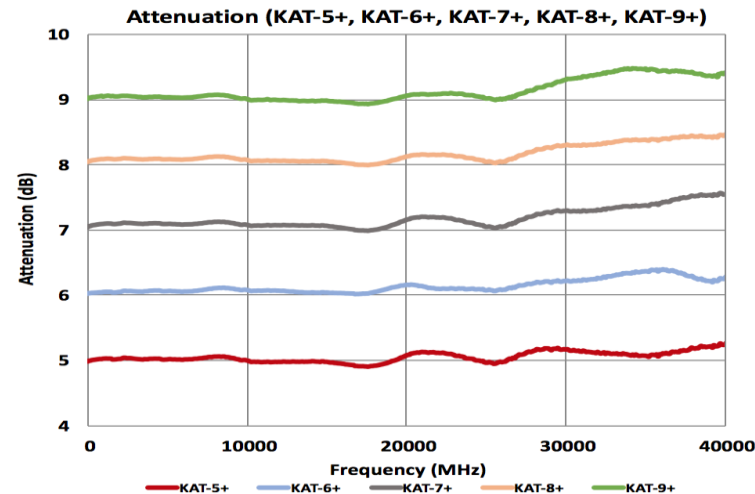
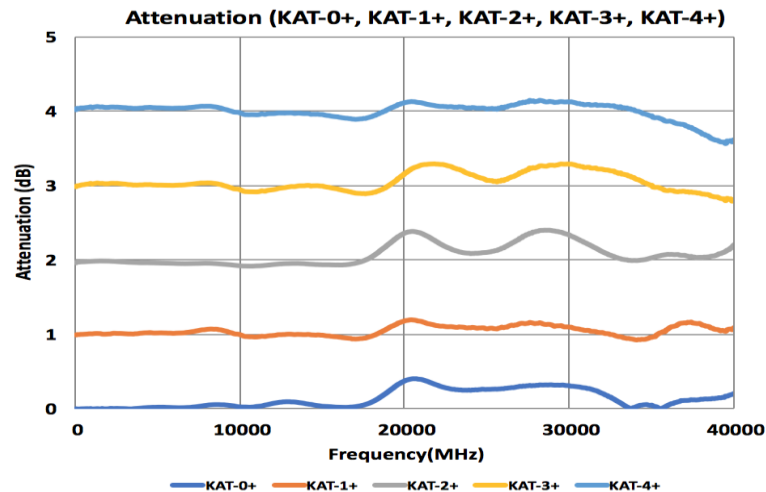
- Super wide bandwidth,
- Wide range of nominal attenuation values (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 30)
- High power handling, up to 2W
- Small size, available in die form and 2 x 2 mm

## Markets

- All Markets



KAT-X+, KAT-X-D+



# Attenuators

DC to 26 GHz

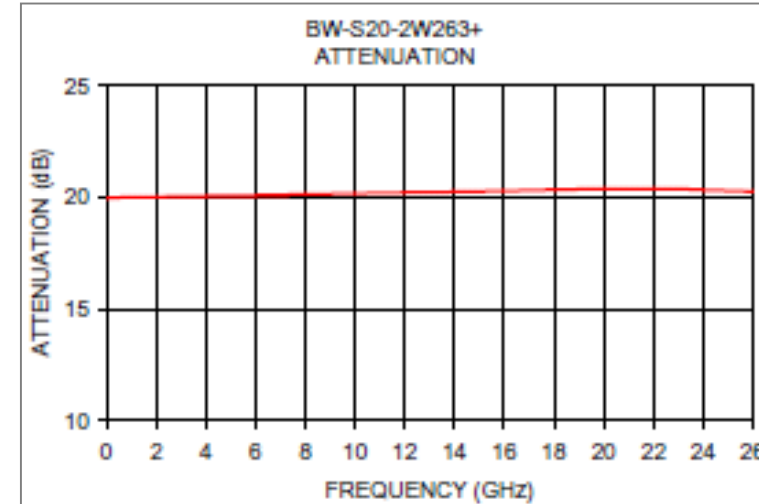
## Key Features

- Input power: 2 watts
- Precise attenuation
- Attenuation flatness:  $\pm 0.5$  dB, typ.



**BW-SX Series**

Model	Attenuation
BW-S1-2W263+	1 dB
BW-S3-2W263+	3 dB
BW-S6-2W263+	6 dB
BW-S10-2W263+	10 dB
BW-S20-2W263+	20 dB





# Precision Fixed Attenuators

DC to 40 GHz

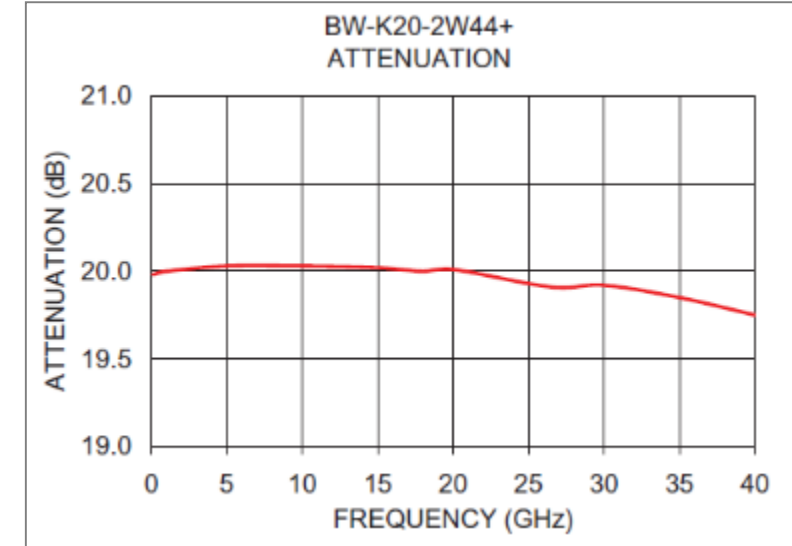
## Key Features

- 2 watt power handling
- Passivated stainless steel connectors
- Connectors: 2.92 mm F/M
- VSWR: 1.20:1 typ.



**BW-Kx Series**

Model	Attenuation (dB)
BW-K1-2W44+	1
BW-K2-2W44+	2
BW-K3-2W44+	3
BW-K4-2W44+	4
BW-K5-2W44+	5
BW-K6-2W44+	6
BW-K10-2W44+	10
BW-K20-2W44+	20



# Precision Fixed Attenuators

DC to 40 GHz

## Key Features

- 2 Watt Power Handling
- Passivated Stainless Steel Connectors
- Connectors: 2.92 mm M/M



BW-KM Series

Model	Attenuation (dB)	Attenuation Accuracy (dB)	VSWR, Max.(:1)	Power (W)
BW-KM3-2W44+	3	+/-0.4	1.2	2
BW-KM6-2W44+	6	+/- 0.5	1.1	2
BW-KM10-2W44+	10	+/- 0.4	1.1	2
BW-KM20-2W44+	20	+/- 0.1	1.1	2

# Precision Fixed Attenuators

DC to 50 GHz

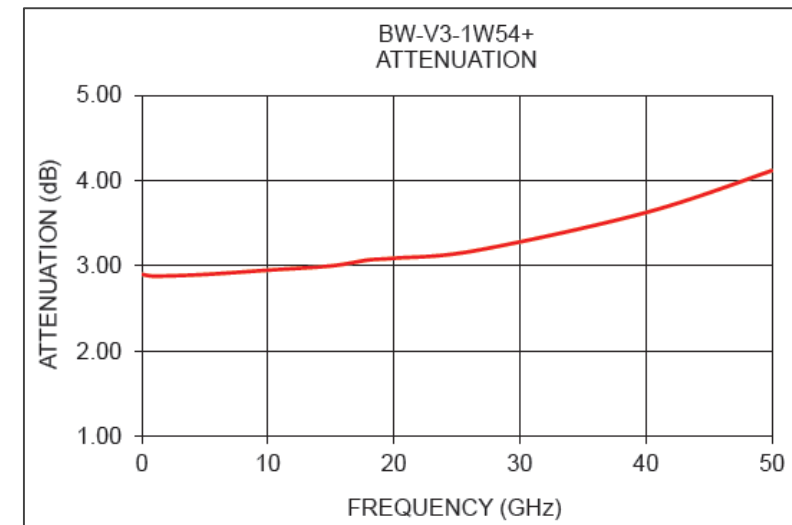
## Key Features

- Input power: 1 Watt max.
- VSWR: 1.20:1 typ.
- Connectors: 2.4 mm Female - 2.4 mm Male
- Passivated stainless steel



**BW-V Series**

Model	Attenuation (dB)
BW-V3-1W54+	3 dB
BW-V6-1W54+	6 dB
BW-V10-1W54+	10 dB
BW-V20-1W54+	20 dB



# Precision Fixed Attenuators

DC to 65 GHz

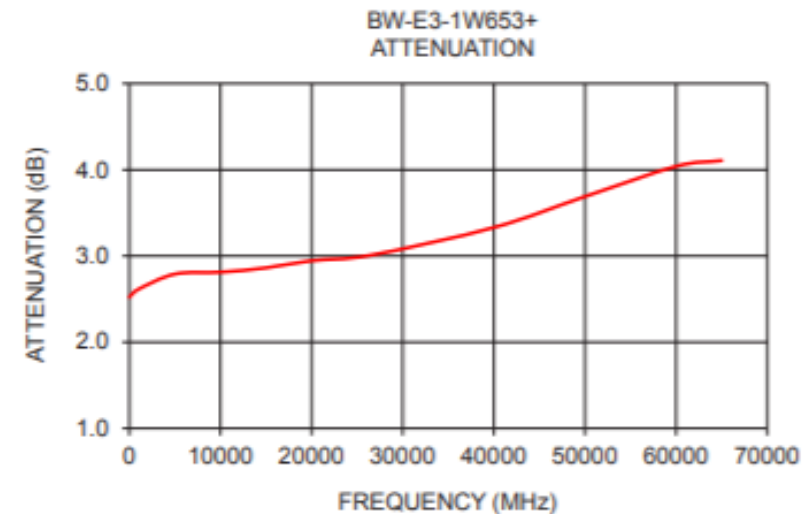
## Key Features

- Input power: 1 Watt max.
- VSWR: 1.3:1 typ. to 65 GHz
- Connectors: 1.85 mm Female – 1.85 mm Male
- Passivated stainless steel



**BW-E Series**

Model	Attenuation (dB)
BW-E1-1E653+	2 dB
BW-E3-1W653+	3 dB
BW-E6-1W653+	6 dB
BW-E10-1W653+	10 dB
BW-E20-1W653+	20 dB



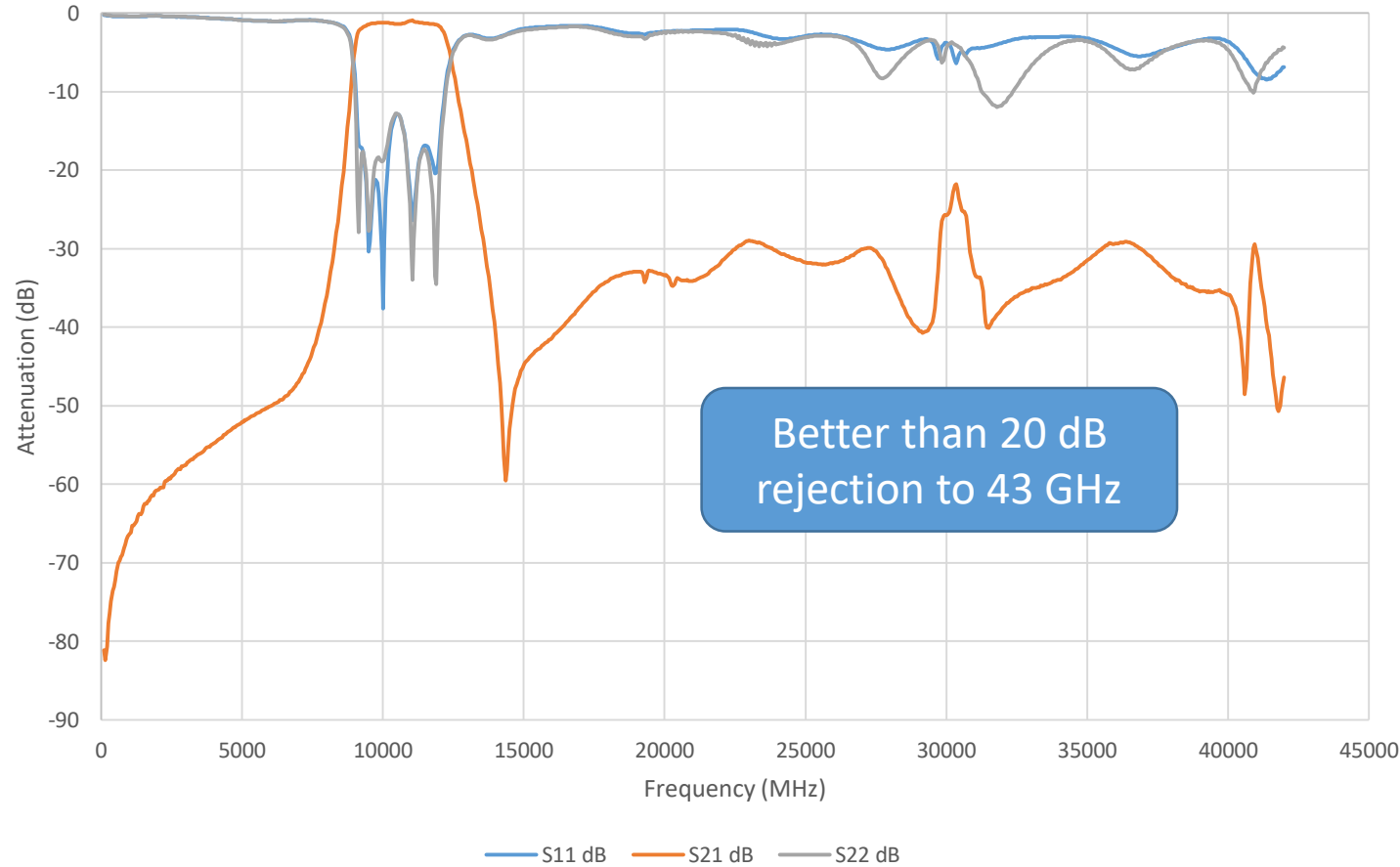
# LTCC Technology Innovation for High Frequencies



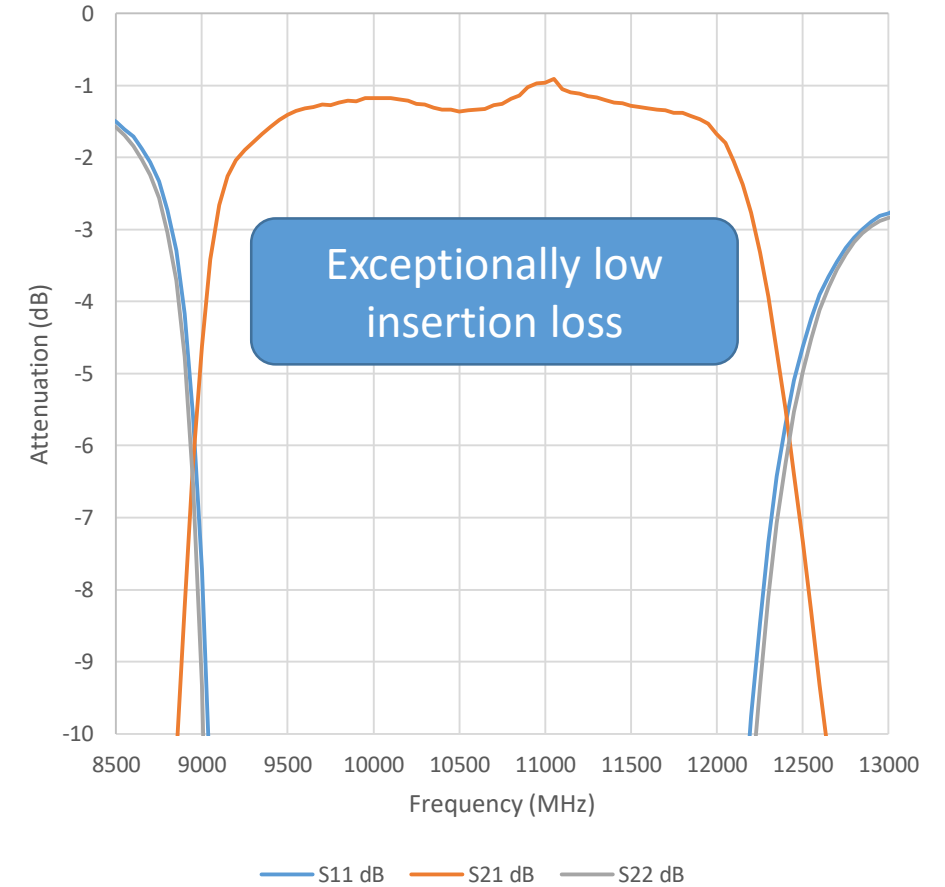
# LTCC Distributed Filters

## X-Band, Ku-Band Distributed Filter Prototype

Distributed Filter Test Data



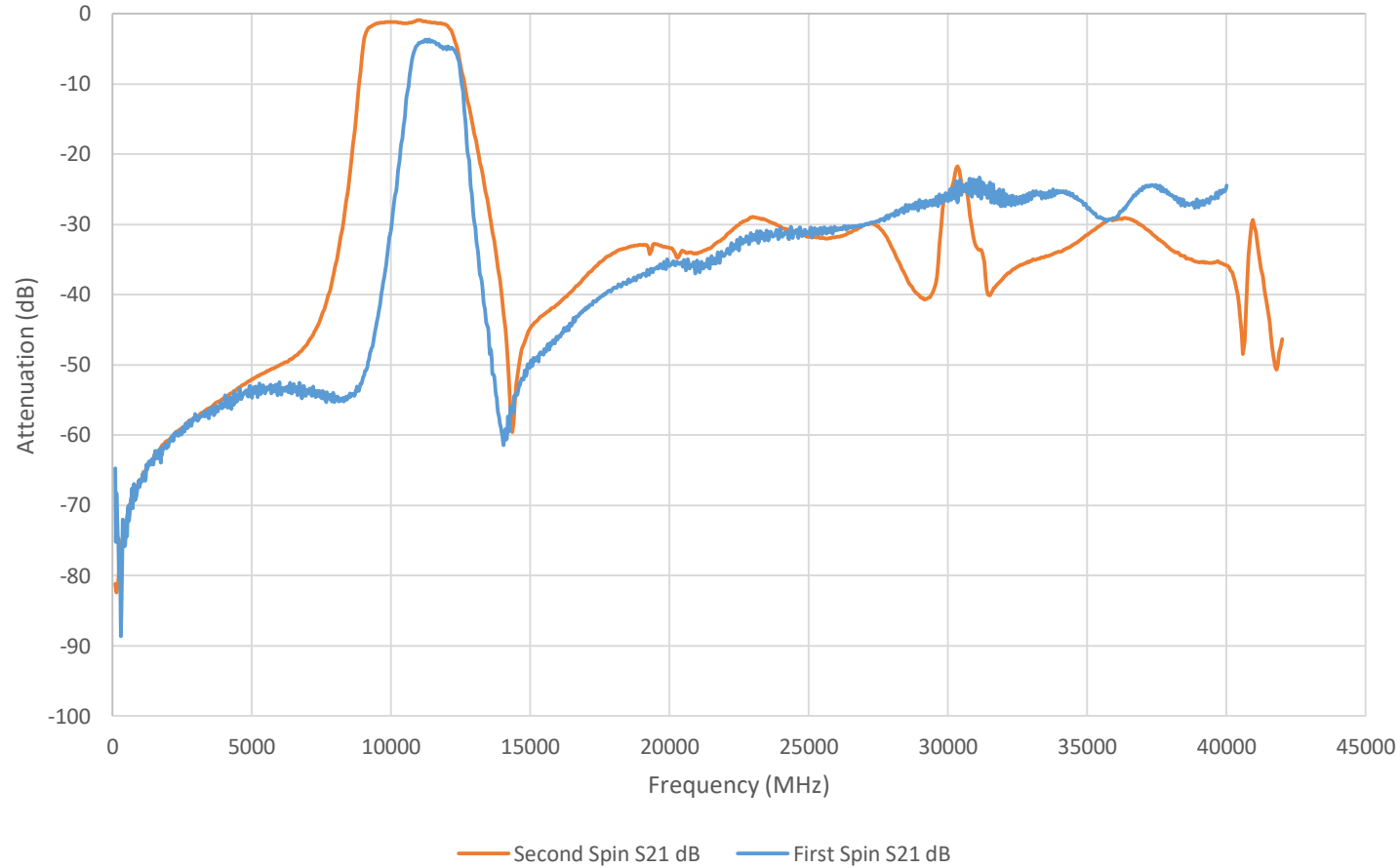
Passband Close-Up



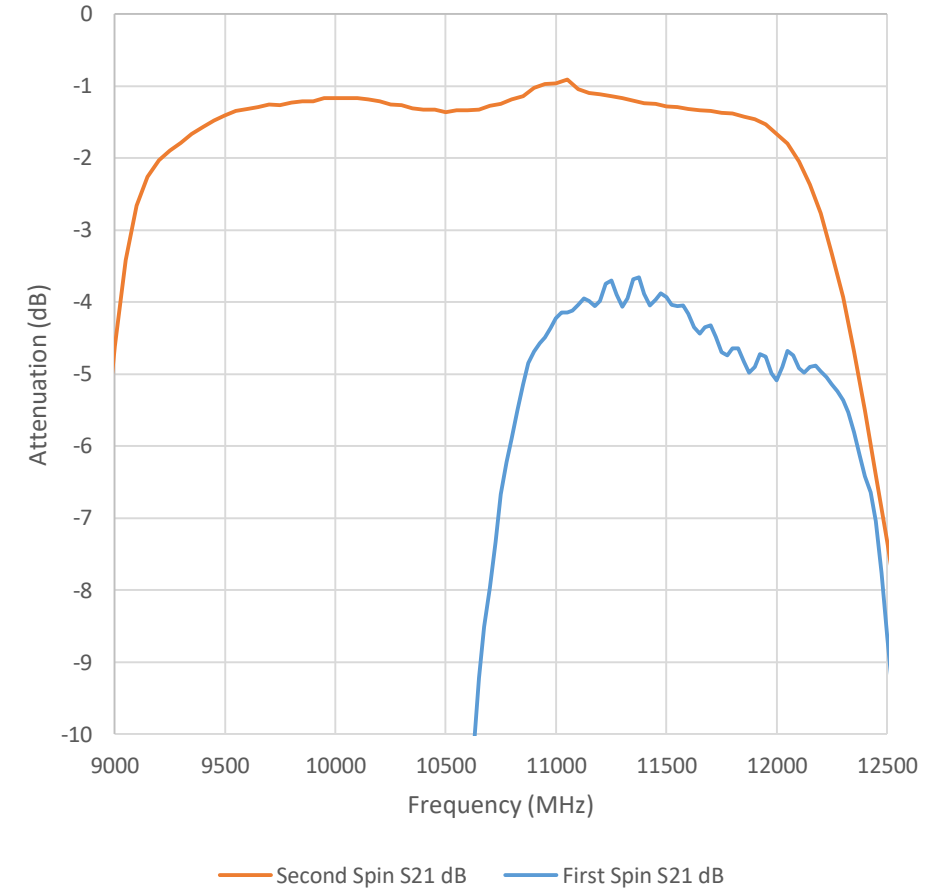
# LTCC Distributed Filters

## 11 to 28% BW Band Pass Filter Prototypes

Distributed Filter Test Data



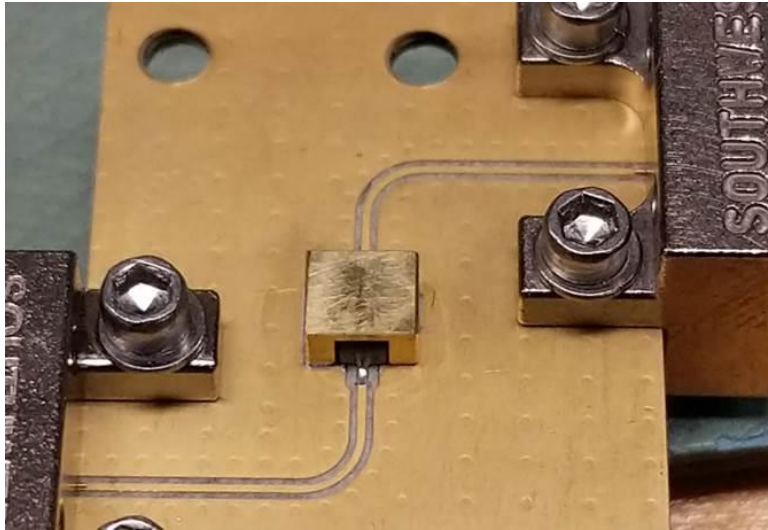
Passband Close-Up



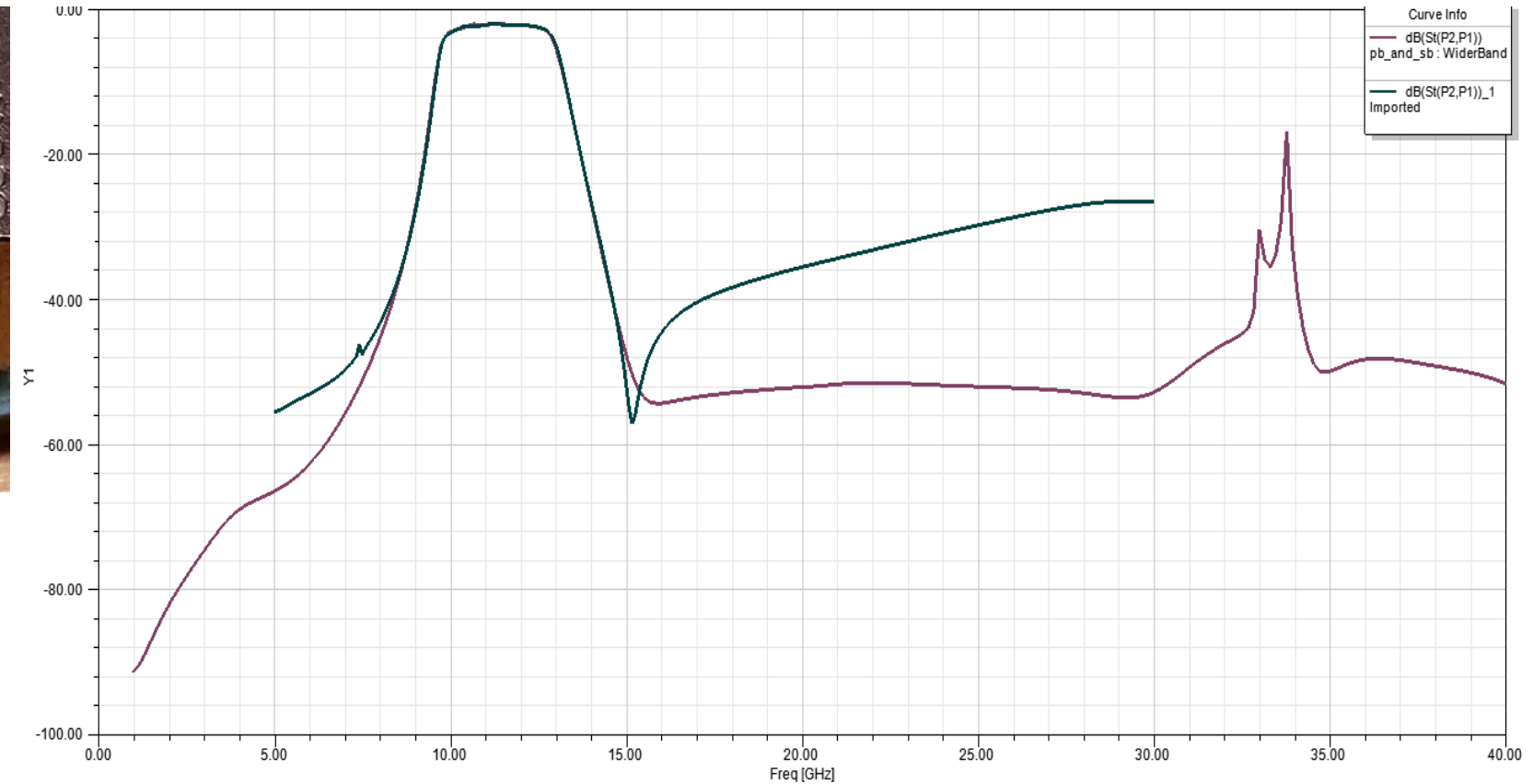
# LTCC Distributed Filters

## Band Pass Filter with improved Shielding

Q2 2019



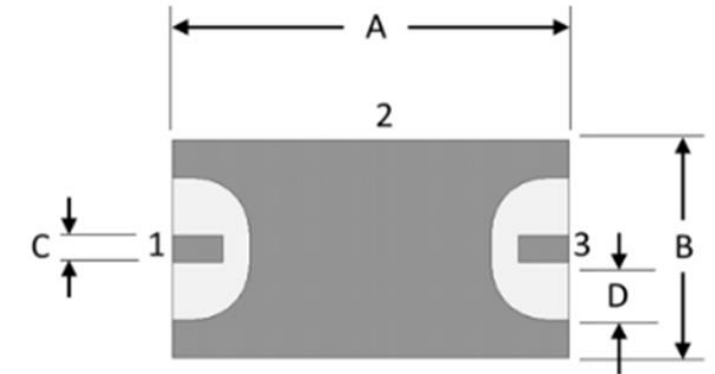
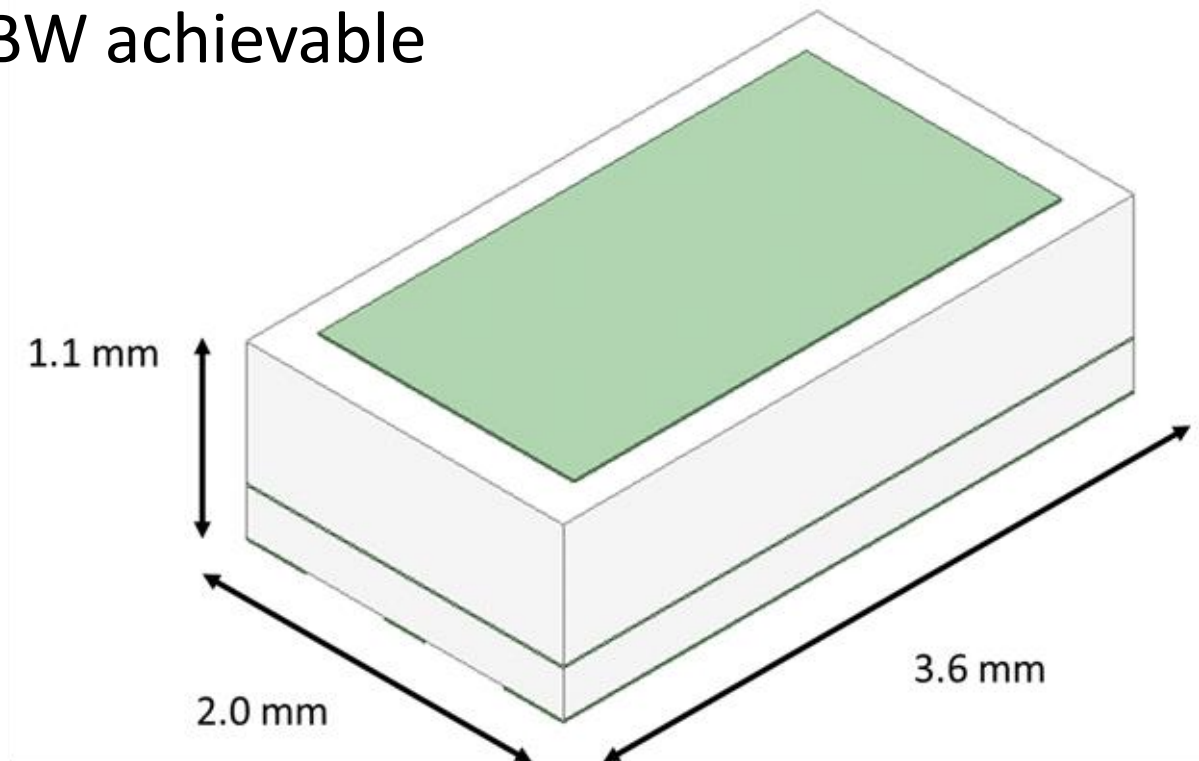
Pick and Place Compatible



# LTCC Substrate Integrated Waveguide Filters

## SIW filter components:

- Band Pass
- 5G Ready
- 4 – 20 %BW achievable



BOTTOM VIEW



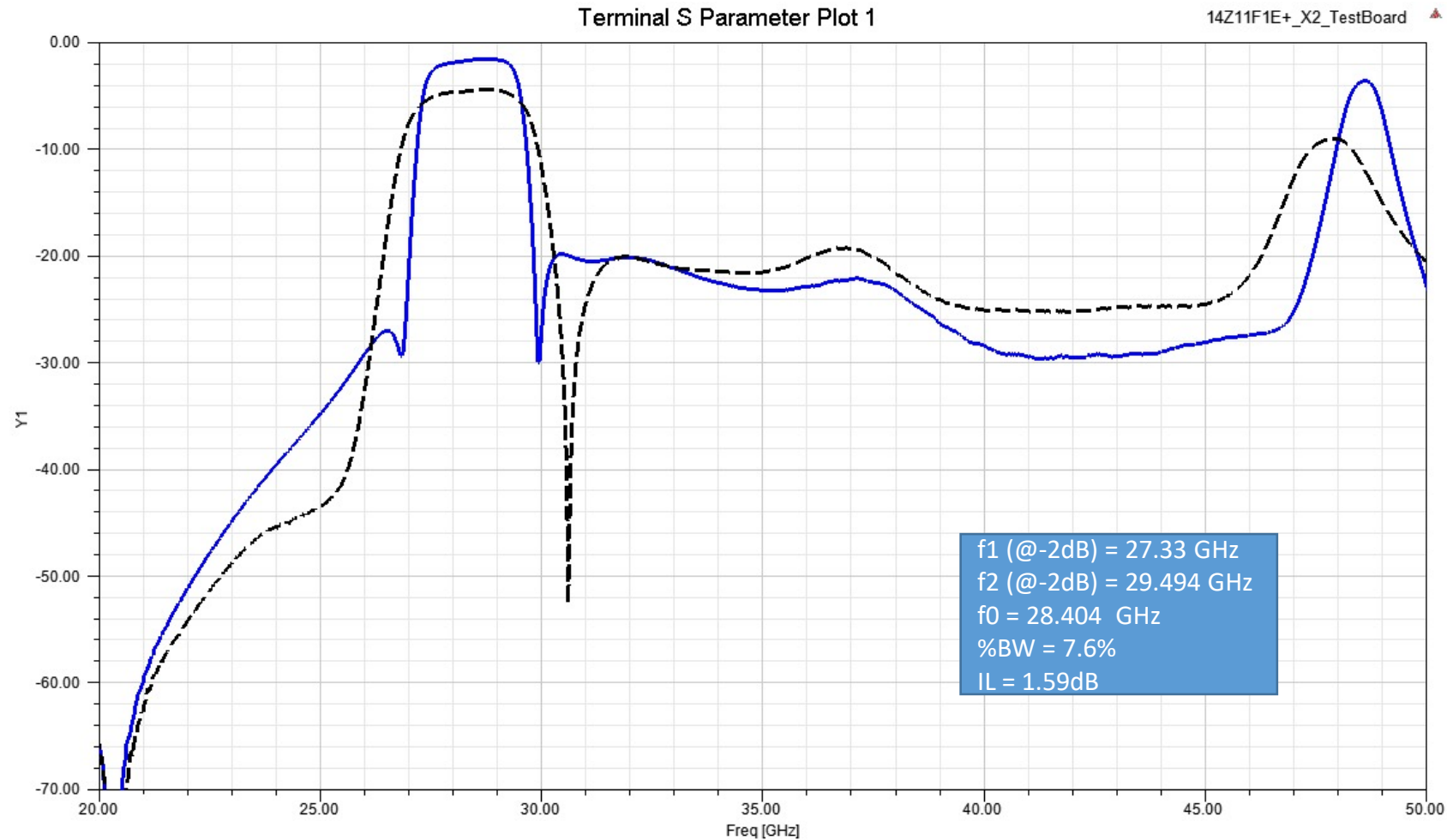
SIDE VIEW

## Outline Dimensions (inch/mm)

A	B	C	D	E
.142	.079	.010	.021	.044
3.60	2.00	0.25	0.53	1.13

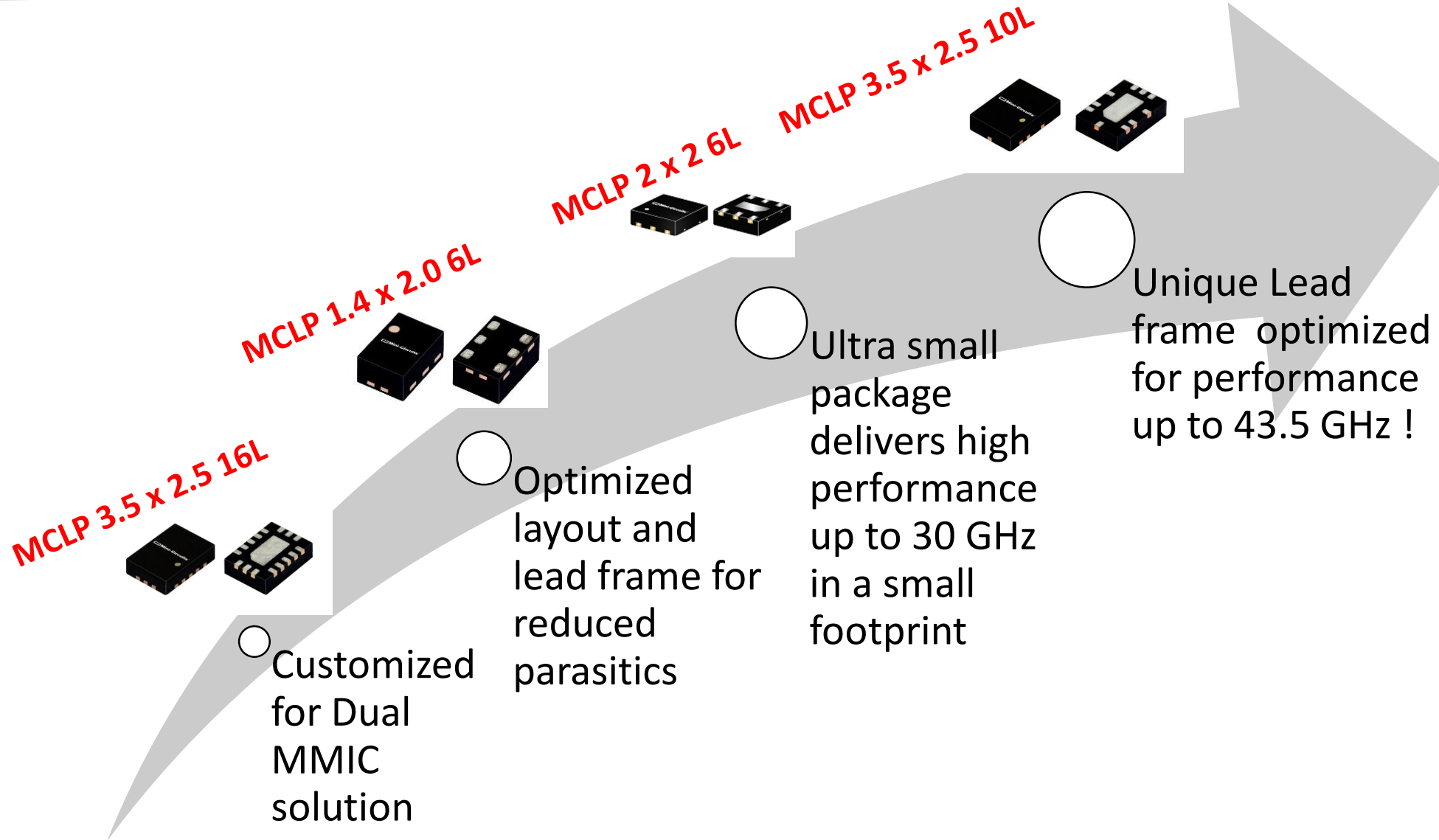
# LTCC Substrate Integrated Waveguide Filters

Q3 2019



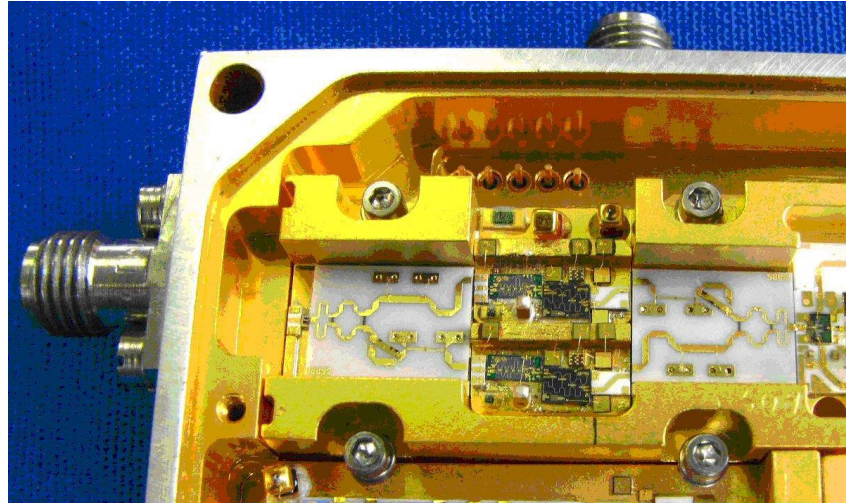
# State of the Art High Frequency Packaging

# Overmolded Package Technology

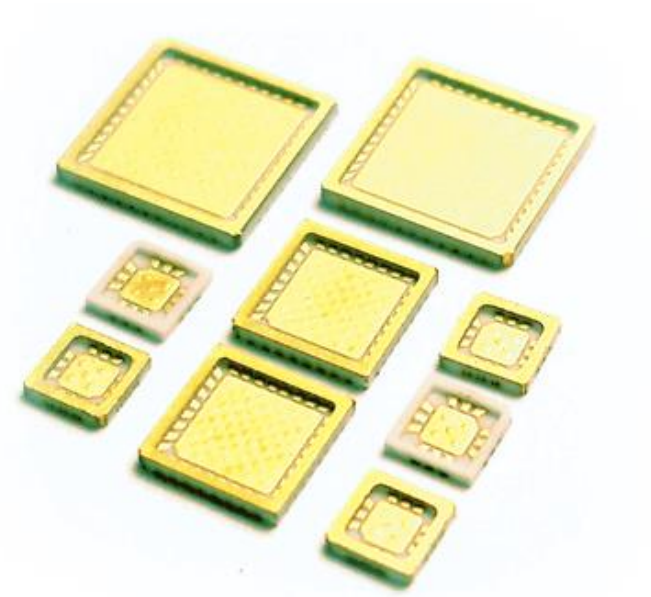




# High Frequency Systems



Chip and Wire

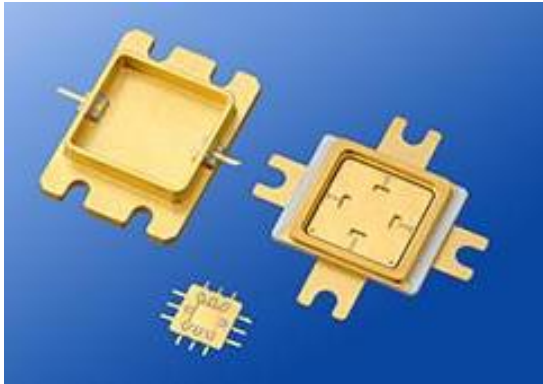


Ceramic

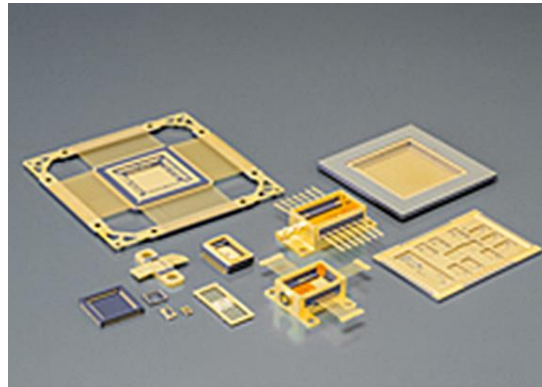
# Ceramic Packaging for 20+ GHz applications

- High Temperature Co-fired Ceramic substrates
- Excellent RF Performance
- Excellent Thermal Performance

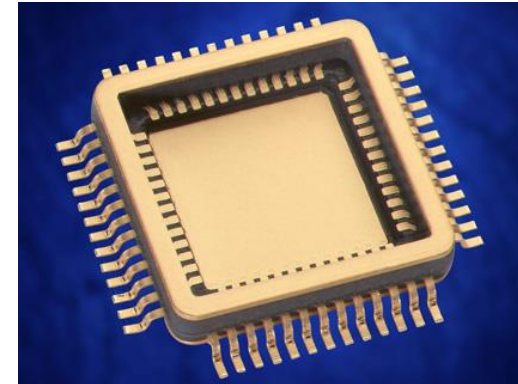
Expensive



High NRE

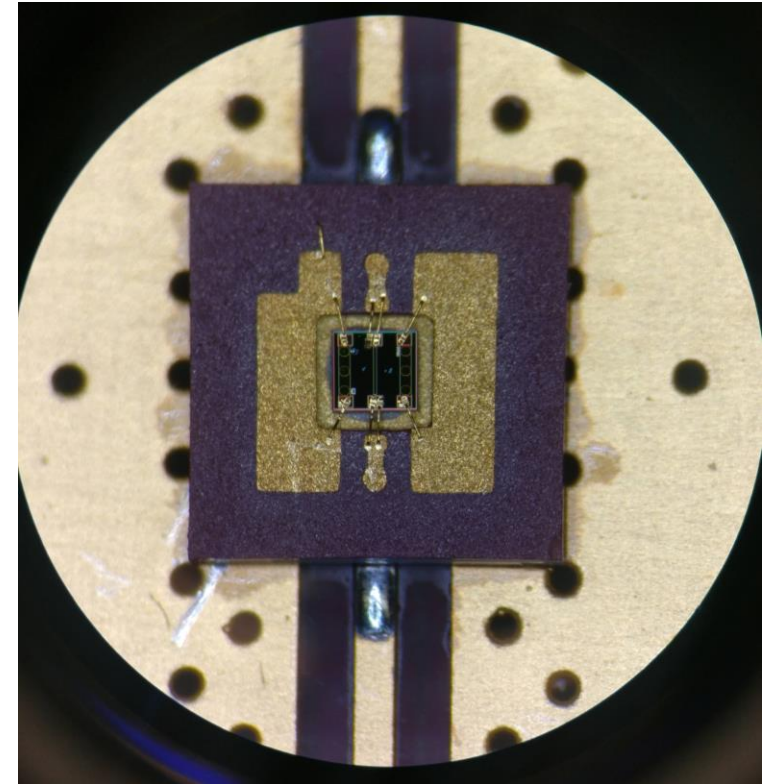
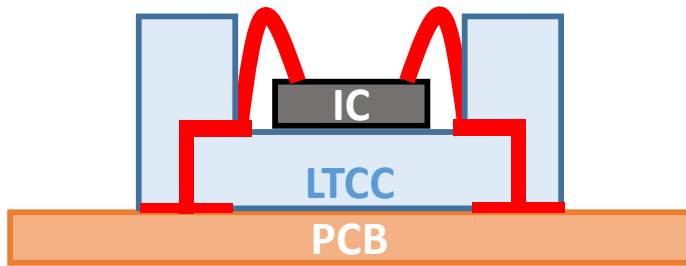


Less Versatile



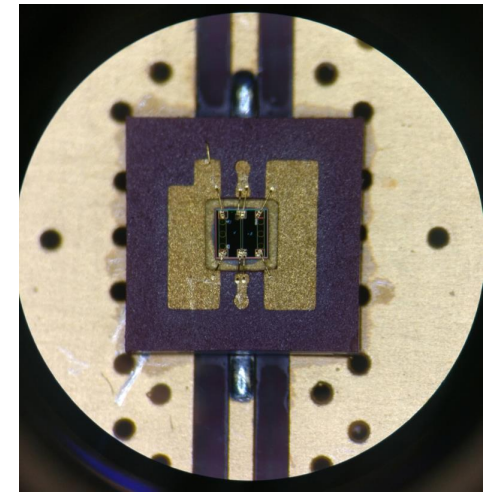
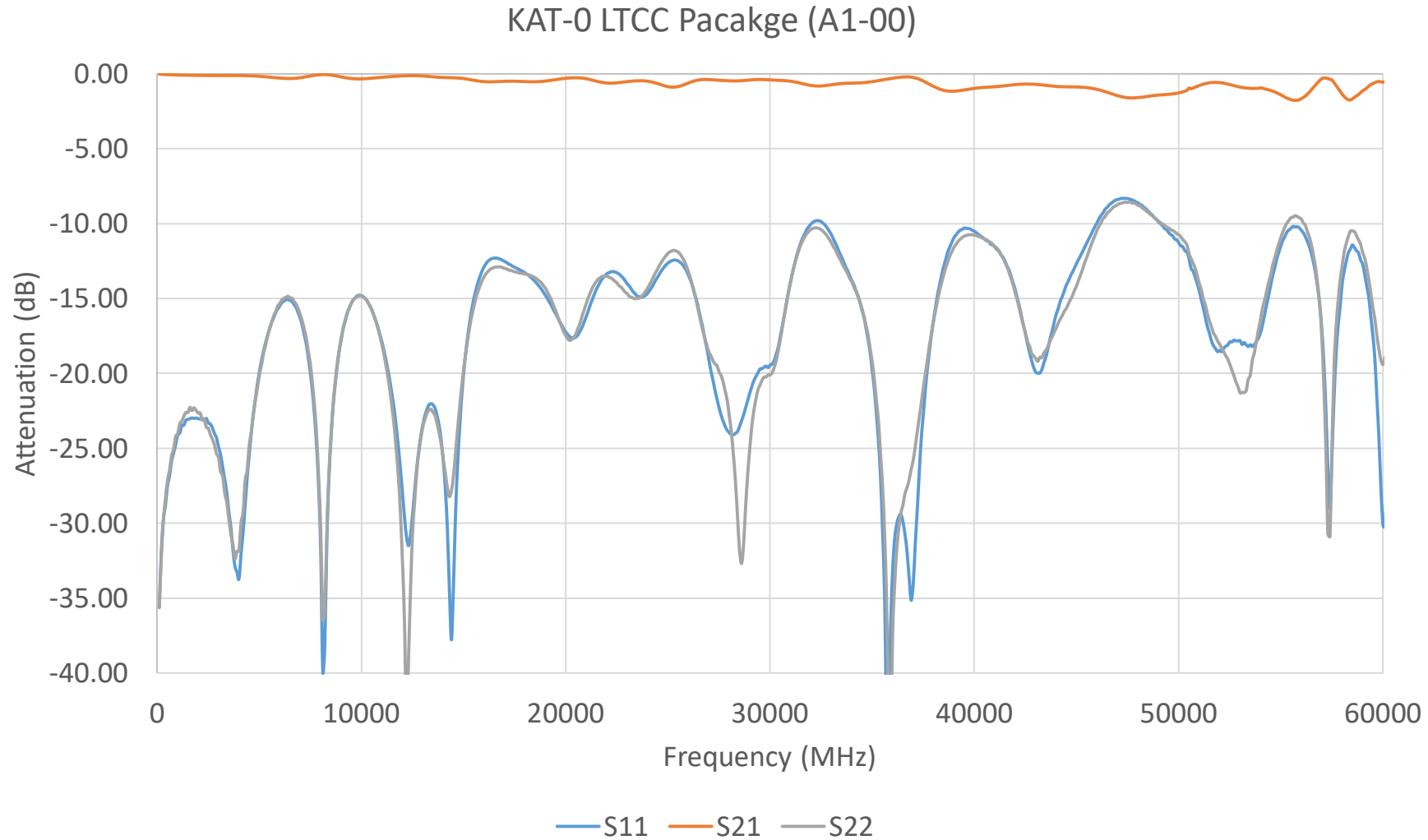
Courtesy: Kyocera, NGK/NTK, Stratedge

# Mini Circuits Solutions



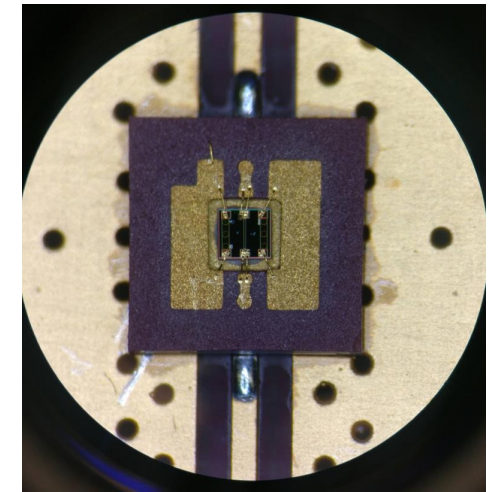
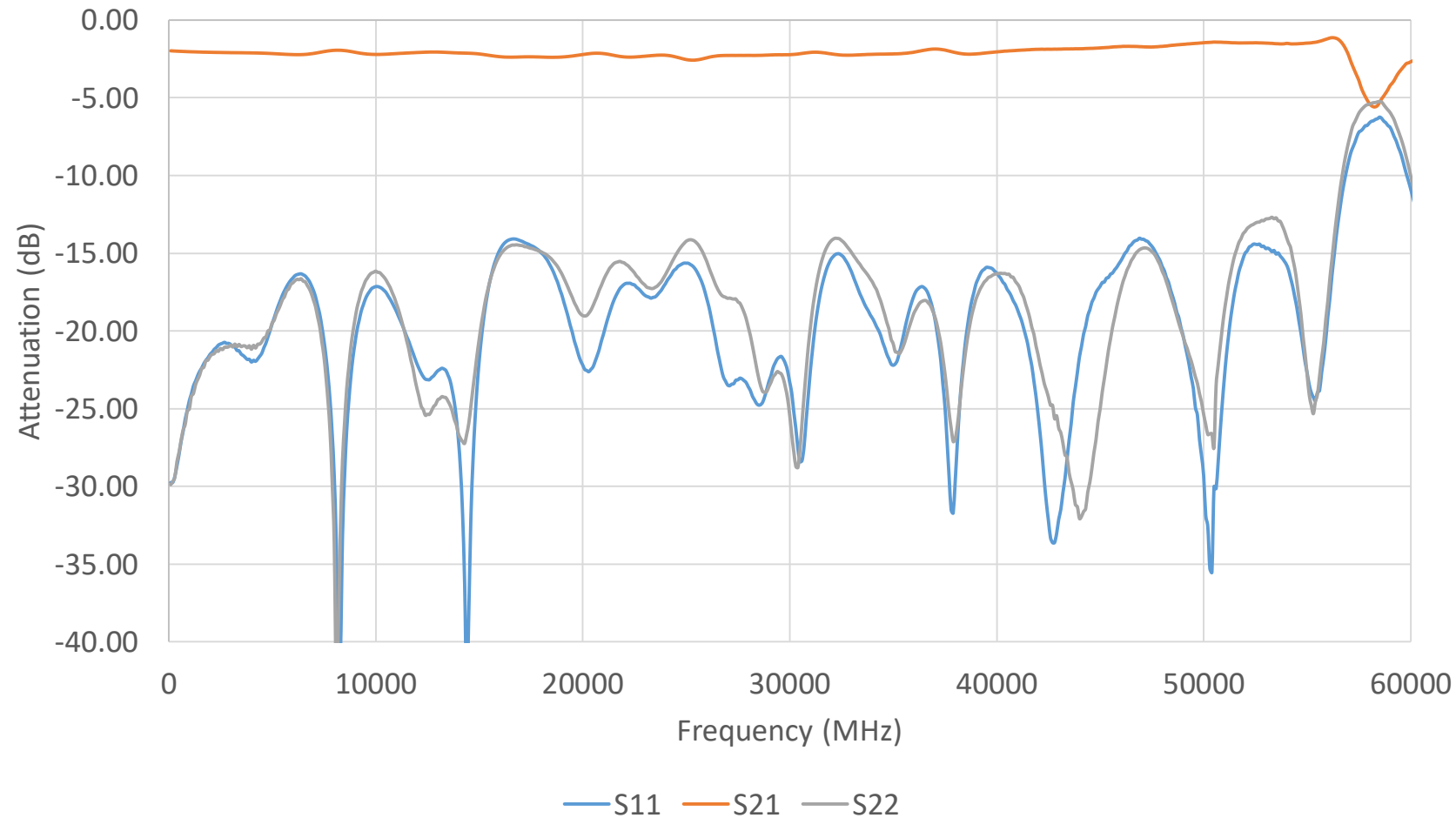
High performance air cavity package, customizable,  
optimized for high volume SMT manufacturing

# LTCC mmWave Packaging Solution



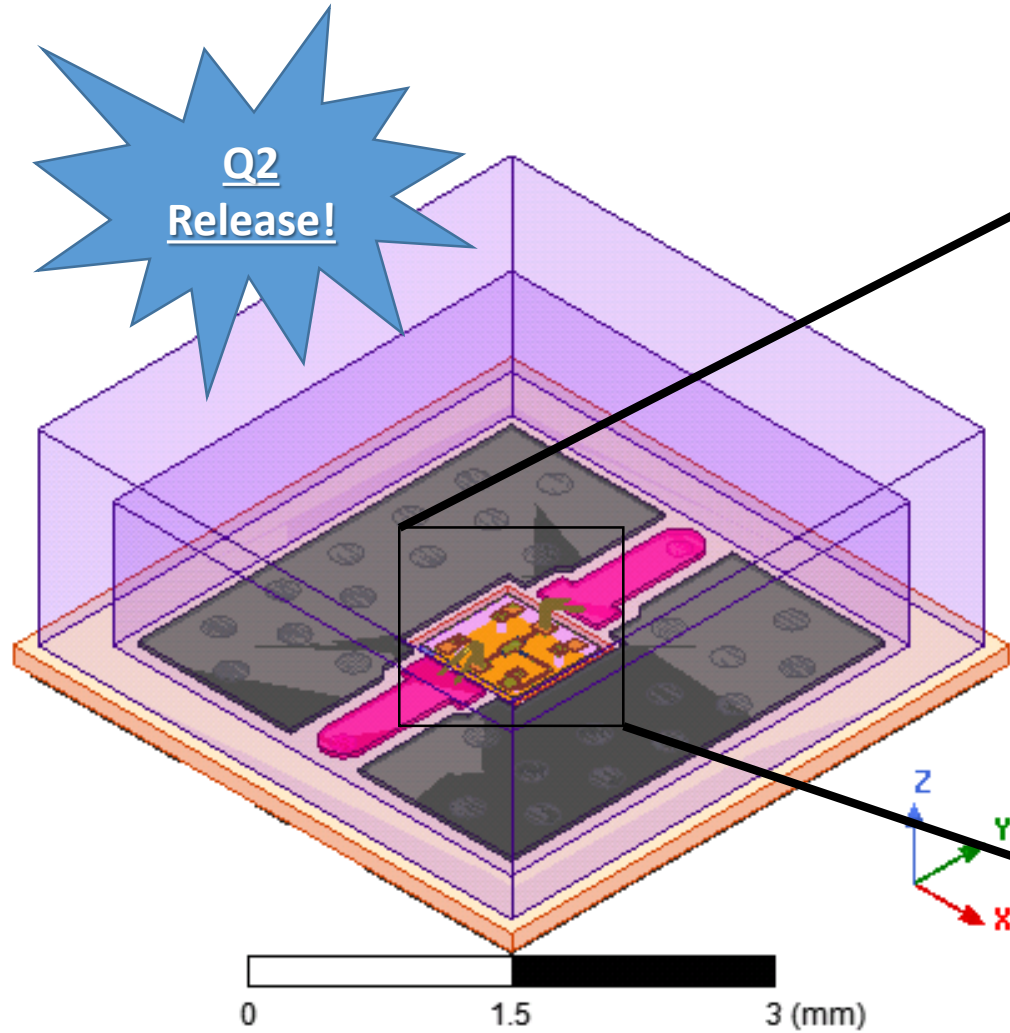
# LTCC mmWave Packaging Solution

KAT-2 LTCC Package (A3-02)

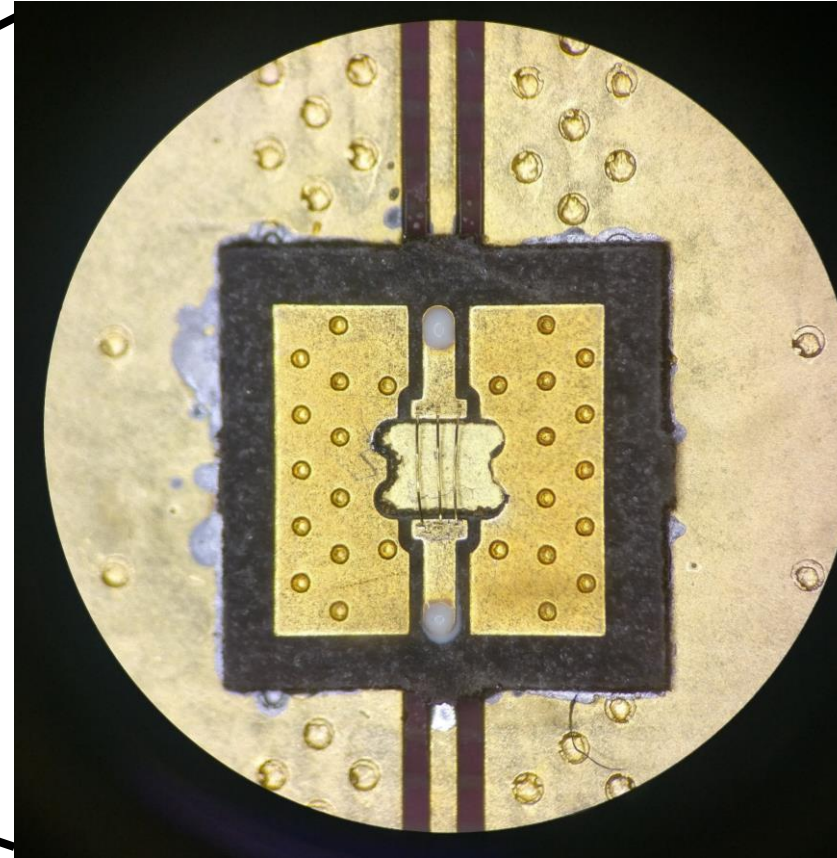




# Organic PCB mmWave Packaging Solution



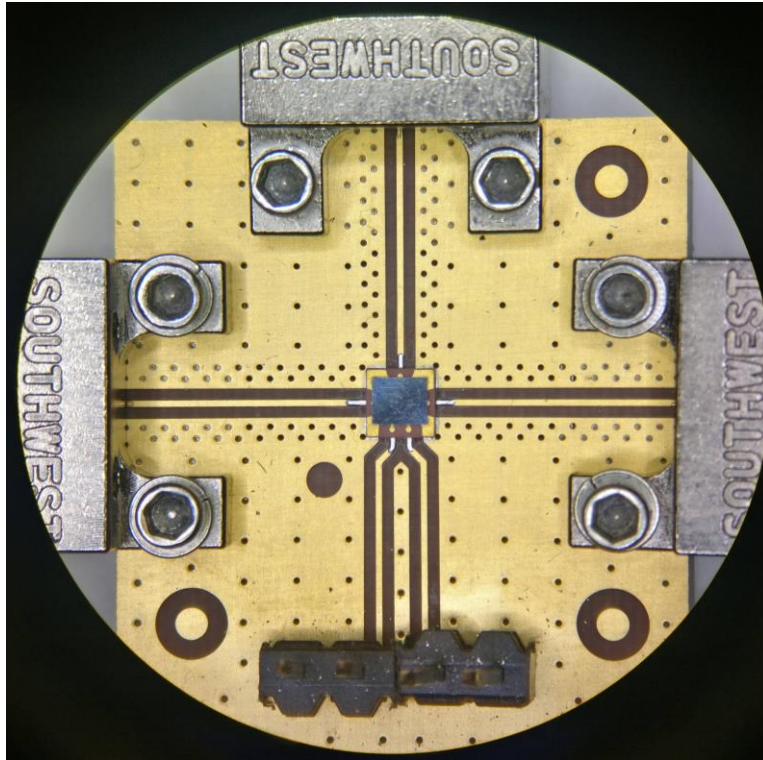
ISOMETRIC VIEW



Drop in die

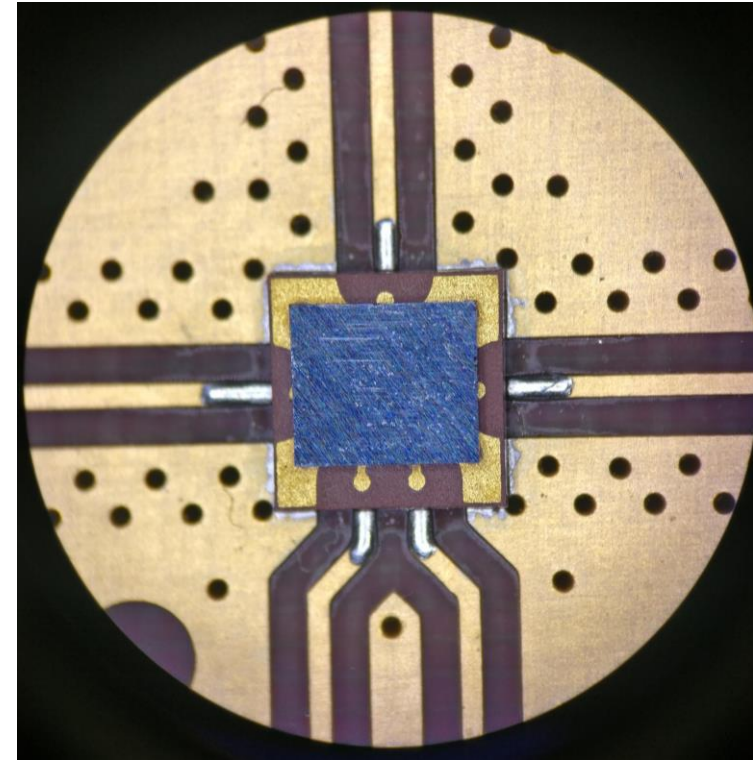
# Flip-Chip Packaging Solution

## SPDT switch assembly



**SPDT Die size:  
2.495mm x 2.149mm**

**Package Dimensions:  
3.0 x 3.0mm**





# Contact Information

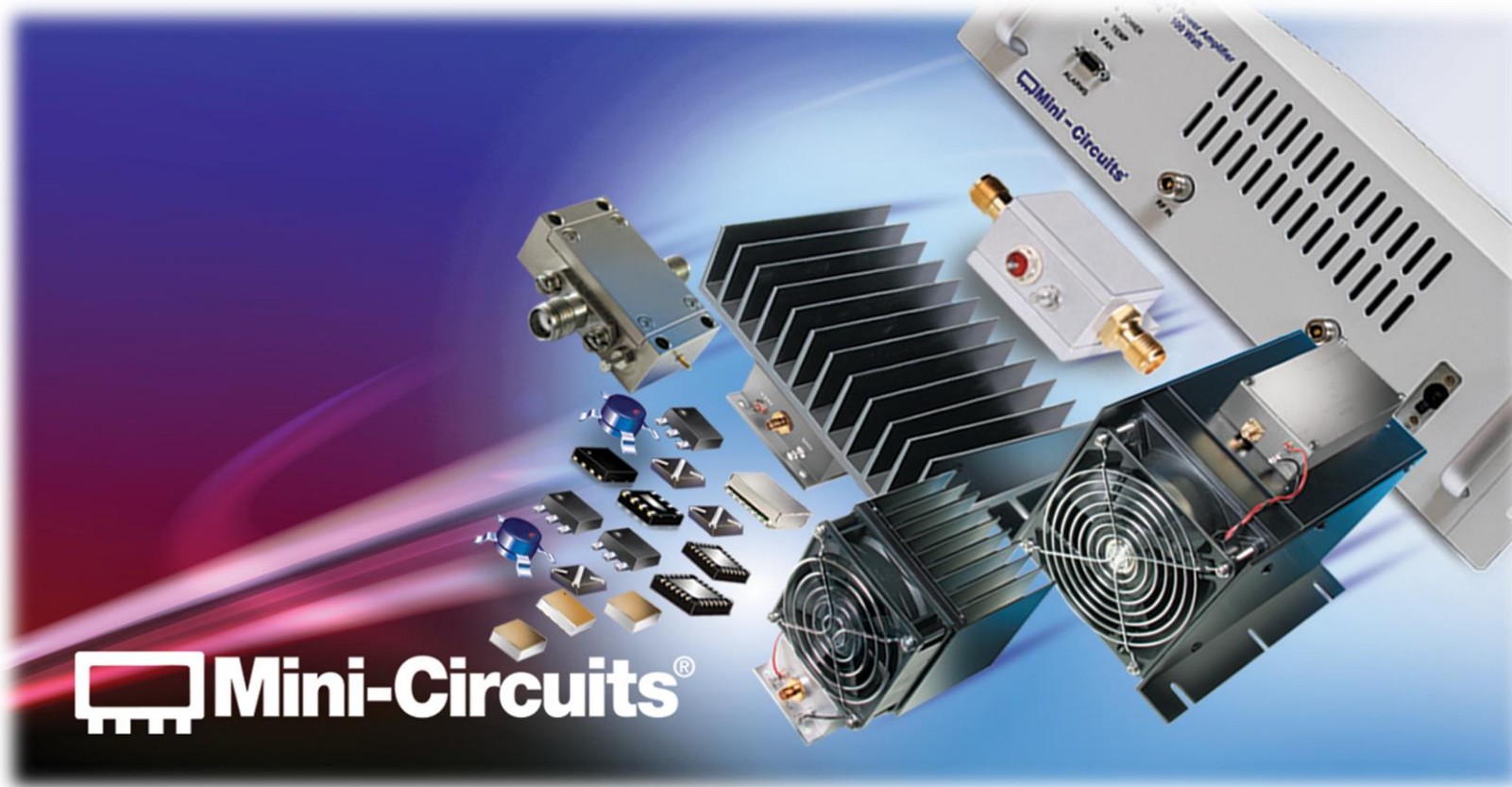
---

Erick A. Olsen  
Product Marketing Manager  
Mini Circuits

[ericko@minicircuits.com](mailto:ericko@minicircuits.com)

+1 978 494 2400

# Your partners for success since 1968



## Thank You